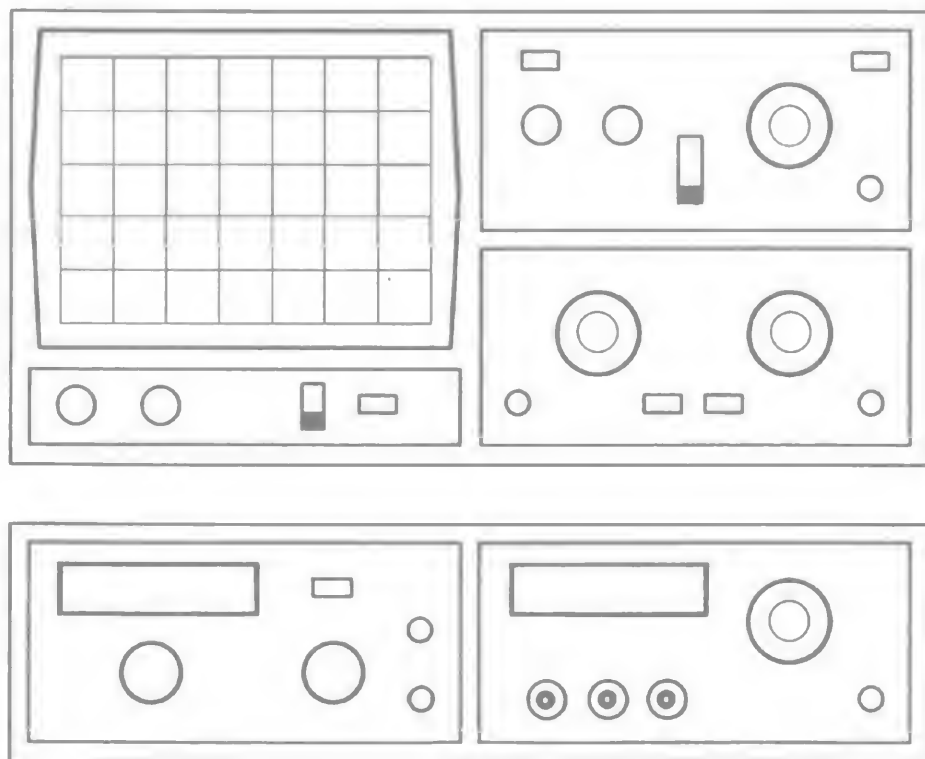


# HAMEG

## Instruments

### MANUAL

#### Oscilloscope HM 103-2



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# Oscilloscope HM 103-2

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## Specification

### Vertical Deflection

**Bandwidth:** DC to 10MHz (−3dB),  
AC to 15MHz (−6dB).  
**Risetime:** approx. 35ns.  
Overshoot: maximum 1%.  
**Deflection coefficient:** 10 calibrated steps,  
5mV/div. to 5V/div. in 1-2-5 sequence, ±3%,  
variable control 1:2.5 to at least **12.5V/div.**  
**Y MAG. x5** (calibrated) to **1mV/div.** ±5%,  
(frequency range DC to 3.5MHz, −3dB).  
**Input impedance:** 1MΩ || 25pF.  
Input coupling: DC-AC-GND.  
Input voltage: max. 400V (DC + peak AC).

### Trigger System

**Automatic** or normal  
with manual level control.  
**Bandwidth:** 2Hz up to at least 30MHz.  
Slope: positive or negative.  
Source: internal or external (BNC connector).  
Coupling: AC, TV (frame) low-pass filter.  
**Threshold:** internal 0.5div., external 0.4V.

### Horizontal Deflection

**Time coefficients:** 18 calibrated steps,  
0.2μs/div. to 0.1s/div. in 1-2-5 sequence,  
variable control 2.5:1 to min. 0.25s/div.  
Accuracy in calibrated position: ±5%.  
Normal length of sweep line: approx. 10div.  
**Bandwidth X-Ampl.:** 2Hz to approx. 850kHz  
**Deflection coefficient:** approx. 0.45V/div.  
Input: BNC connector (on front panel).  
X-Y phase shift: <3° up to 70kHz.

### Component Tester

**Test voltage:** max. 7.5V rms (open circuit).  
**Test current:** max. 23mA rms (shorted).  
**Test frequency:** 50-60Hz (line frequency).  
Test connection: 2 banana jacks 4mm dia  
One test lead is grounded (Safety Earth)

### General Information

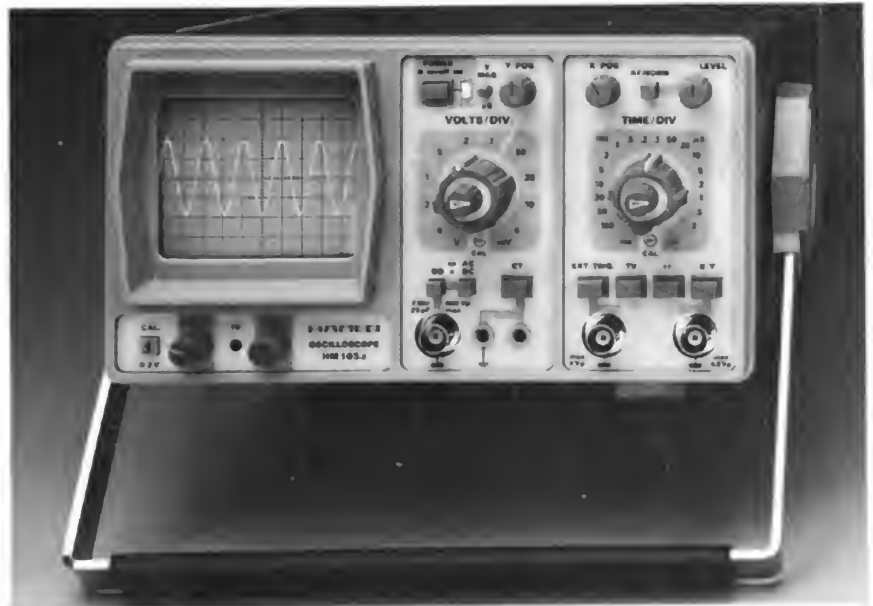
**Cathode-ray tube:** ER 100 (P43 phosphor),  
rectangular screen, internal graticule 8x10div.  
Accelerating potential: 1950V.  
Trace rotation: adjustable on front panel.  
**Calibrator:** square-wave generator approx. 1kHz  
for probe compensation and Y calibration;  
output (on front panel): 0.2V ±1%.  
**Electronic regulation** for all important  
supply voltages including high voltage.  
**Protective system:** Safety Class I (IEC 348)  
Line voltages: 110, 125, 220, 240V AC.  
Permissible line fluctuation: ±10%.  
Line frequency range: 50 to 60Hz.  
**Power consumption:** approx. 21 Watt.  
Weight: approx. 3.7kg.  
Cabinet (mm): **W** 212, **H** 114, **D** 280.  
Colour: techno-brown.  
Lockable tilt handle.  
Subject to change.

### Test Displays

using the Component Tester

Transistor

Diode



## 10MHz Compact-Oscilloscope

**1 Channel, max. 1mV/div. Sensitivity**

**Timebase: 0.25s/div. to 0.2μs/div., triggering up to 30MHz;**

**Built-in Component Tester.**

The compact **HM 103-2** was developed specifically for field service, technical vocational schools and the advanced hobbyist. It has an impressive **1mV/div.** vertical input sensitivity, and input signals as small as 0.5div. are enough to trigger the timebase at frequencies up to **30MHz**. The **HM 103-2** offers the user two trigger modes: Automatic or Normal. In the Normal mode, triggering is controlled by the Level control. A **TV low-pass filter** is a standard feature, which permits the display of video signals at the frame frequency.

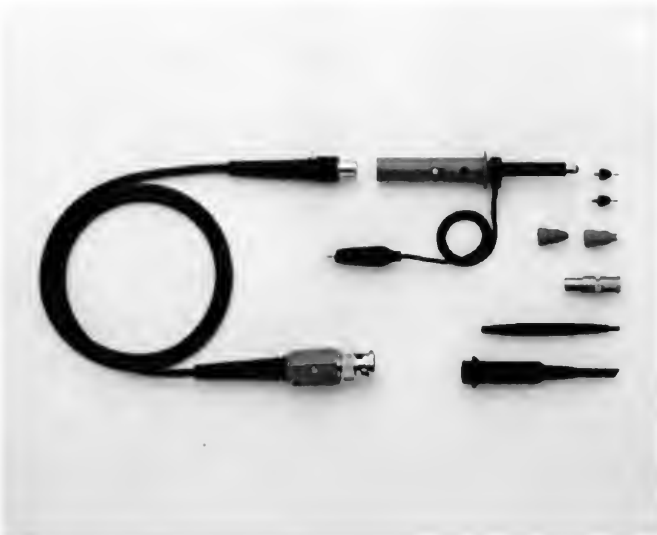
A **component tester** is also provided as a standard feature of the **HM 103-2**. This allows the user to perform quick tests of electronic components including resistors, diodes, ICs, capacitors, inductors, and transistors, either in or out of circuit. A single pushbutton switches from oscilloscope operation to component tester mode.

A bright, sharply-focused, fully-shielded CRT with **internal graticule** ensures parallax-free viewing – essential for a variety of maintenance and monitoring tasks. All critical supply voltages are electronically regulated. The display will remain stable even under conditions of wide-range voltage fluctuations. A 0.2V squarewave signal is provided at the front panel for setting probe compensation and checking vertical gain calibration.

The **HM 103-2** offers exceptional feature content for a 10MHz oscilloscope, particularly in comparison with other oscilloscopes in this class. Compact design, light weight, rugged construction, ease of operation and long-term reliability make the **HM 103-2** an indispensable instrument for shop, field service, and school application.

### Accessories supplied

**10:1 Probe, Line cord, Operators Manual.**



## Modular Probes

The clear advantage over ordinary probes are field replaceable parts and the HF-compensation feature on the 10:1 attenuator probes. For the first time, probes in this price range allow adjustments of their HF-characteristics to match individually the input impedance of each scope. This is particularly important for scopes with higher bandwidths (>50MHz), as otherwise strong overshoot or rounding may occur, when measuring fast-rising square waves. An exact HF-compensation, however, is only possible with square-wave generators having a risetime <5ns. Most HAMEG scopes already feature such a calibration generator. For other oscilloscopes, it is available as accessory item HZ60-2. At present the following Modular Probes are available (HZ36 without HF-compensation):

Type	HZ36 selectable	HZ51	HZ52	HZ53	HZ54 selectable
Attenuation Ratio	1:1/10:1	10:1	10:1 (HF)	100:1	1:1/10:1
Bandwidth min. (MHz)	10/ 100	150	250	150	10 / 150
Risetime (ns)	35/3.5	<2	<1.4	<2	35/<2
Inp. Capacitance (pF)	47/18	16	16	6.5	40/18
Inp. Resistance (MΩ)	1/10	10	10	100	1/10
Inp. Voltage max. (V <sub>p</sub> )	600	600	600	1200	600
Cable Length (m)	1.5	1.2	1.5	1.5	1.2

Spare Cable for HZ36	<b>HZ39</b>
Spare Cable for HZ51, HZ54	<b>HZ57</b>
Sparepart Kit (2 sprung hooks, 2 screw tips, 1 ground cable)	<b>HZ40</b>

## Demodulator Probe

**HZ55**

Special probe for AM-demodulation and wobulator measurements. HF-Bandwidth 100kHz - 500MHz (±1dB). AC Input Voltage 250mV - 50V<sub>rms</sub>. DC Isolation Voltage 200V DC including peak AC. Cable length 1.2m.

## High Voltage Probe

**HZ58**

For measurement of voltages up to 15kV<sub>pp</sub>. Input resistance approx. 500MΩ. Recommended load resistance 1MΩ/10MΩ (switchable). Attenuation ratio 1000:1. Bandwidth 1MHz. Cable length 1.5m. BNC connector.

## Test Cable Banana - BNC

**HZ32**

Coaxial test cable; length 1.15m, characteristic impedance 50Ω. Cable capacitance 120pF. Input voltage max. 500V<sub>p</sub>.

## Test Cable BNC - BNC

**HZ34**

Coaxial test cable; length 1m, characteristic impedance 50Ω. Cable capacitance 126pF. Input voltage max. 500V<sub>p</sub>.

## Adapter Banana - BNC

**HZ20**

Two 4mm binding posts (19mm between centers) to standard BNC male plug. Input voltage max. 500V<sub>p</sub>.

## 50Ω Through-Termination

**HZ22**

For terminating systems with 50Ω characteristic impedance. Maximum load 2W. Max. voltage 10V<sub>rms</sub>.

## Carrying Cases

For HM103	<b>HZ95</b>
For HM203, HM204, HM205, HM208, HM408, HM604, HM605 and HM1005	<b>HZ96</b>

## Viewing Hood

**HZ47**

For HM203, HM204, HM205, HM208, HM408, HM604, HM605 and HM1005

## Scope-Tester

**HZ60-2**

For Checking the Y amplifier, timebase, and compensation of all probes, the HZ60-2 is a crystal-controlled, fast rising (typ. 3ns) square-wave generator with switchable frequencies of DC, 1-10-100Hz, 1-10-100kHz, and 1MHz. Three BNC outputs provide signals of 25mV<sub>pp</sub> into 50Ω, 0.25V<sub>pp</sub> and 2.5V<sub>pp</sub> (open circuit for 10x and 100x probes); accuracy ±1%. Battery-powered.

## Component-Tester

**HZ65**

Indispensable for trouble-shooting in electronic circuits. Single component and in-circuit tests are both possible. The HZ65 operates with all scopes, which can be switched to X-Y operation (ext. horizontal deflection). Non-destructive tests can be carried out on almost all semiconductors, resistors, capacitors, and coils. Two sockets provide for quick testing of the 3 junction areas in any small power transistor. Other components are connected by using 2 banana jacks. Test leads supplied.

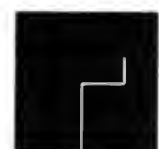
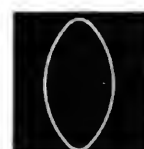
## Examples of Test Displays:

Short circuit

Capacitor 33μF

Junction E-C

Z-Diode <8V



## General Information

The new HM 103-2 is as easy to use as all HAMEG instruments. Technologically it represents the latest state of engineering in this price range. This is particularly illustrated by the increased use of monolithic integrated circuits. The logical arrangement of the controls and connectors on the front panel ensures that the user will quickly become familiar with the operation of the instrument. However, even experienced operators are advised to read the following instructions thoroughly, as they include important information relating to the use of the HM 103-2.

The front panel is subdivided into three sections according to the various functions. The **INTENS.** (intensity), **FOCUS**, and **TR** (trace rotation) controls are arranged directly below the screen of the cathode-ray tube (CRT). Also the calibrator output (**CAL. 0.2V**) is located in this section.

The Y-Section, located on the right of the screen, contains the red **POWER** pushbutton and indicating LED, the vertical input BNC connector with its input coupling pushbutton (**AC/DC**), the **GD** (ground) pushbutton, and the **CT** (Component Tester) pushbutton with two banana jacks. Furthermore, the Y-Section contains the **Y-AMPL.** input attenuator switch with its variable control, **Y-POS.** (position) control, and the **Y-MAG.x5** pushbutton.

All operating controls for **TIMEBASE**, triggering, and **X-POS.** are arranged on the right side of the front panel in the X-Section. This section contains five pushbuttons and two input BNC connectors for external triggering and external horizontal deflection.

The instrument is so designed that even incorrect operation will not cause serious damage. The pushbuttons control only minor functions, and it is recommended that before commencement of operation all pushbuttons are in the "out" position. After this the pushbuttons can be operated depending upon the mode of operation required. For a better understanding of these Operating Instructions the front panel picture at the end of these instructions can be unfolded for reference alongside the text.

The HM 103-2 accept all signals from DC (direct voltage) up to a frequency of at least 10MHz (-3 dB). For sinewave voltages the upper frequency limit will be 20-25MHz. However, in this higher frequency range the vertical display height on the screen is limited to approx. 2 div. In addition, problems of time resolution also arise. For example, with 10MHz and the fastest adjustable sweep rate (200 ns/div.), one cycle will be displayed every 0.5 div. The tolerance on indicated values amounts to  $\pm 3\%$  in the vertical and  $\pm 5\%$

in the horizontal deflection direction. All values to be measured can therefore be determined relatively accurately. However, from approximately 3MHz upwards the measuring error will increase as a result of loss of gain. At 8MHz this reduction is about 10%. Thus, approximately 11% should be added to the measured voltage at this frequency. As the bandwidth of the amplifiers differ (normally between 10 and 15MHz), the measured values in the upper limit range cannot be defined exactly. Additionally, as already mentioned, for frequencies above 10MHz the dynamic range of the display height steadily decreases. The vertical amplifier is designed so that the transmission performance is not affected by its own overshoot.

## Warranty

Before being shipped each instrument must pass a 10 hour quality control test. Almost every early failure can be detected by means of intermittent operation during this test. Nevertheless, a component may fail but only after a longer period of operation. Therefore, **all HAMEG instruments are under warranty for a period of two years**, provided that the instrument has not undergone any modifications. HAMEG will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. HAMEG is not liable for consequential damages. It is recommended that the instrument be repackaged in the original manner for maximum protection. We regret that transportation damage due to poor packaging is not covered by this warranty.

In case of any complaint, attach a tag to the instrument with a description of the fault observed. Please supply name and department, address and telephone number to ensure rapid service.

## Safety

This instrument is designed and tested according to international safety standards (e.g. **IEC 348: Safety requirements for electric measuring apparatus**). The instrument has left the factory in perfect safety condition. To preserve this state and to ensure operation without danger, the user must observe all advises and warning remarks in these Operating, Test, and Service Instructions. **The case, chassis, and all measuring terminals are connected to the Safety Earth conductor.** The specification of the instrument corresponds to **Safety Class I** (three-conductor AC power cable). The grounded accessible metal parts (case, sockets, jacks) and the power line circuit of the HM 103-2 are tested against one another with 2000V 50Hz. Under certain conditions, 50Hz or 60Hz hum voltages can occur in the



measuring circuit due to interconnection with other mains/line powered instruments or devices. This can be avoided by using a protective isolating transformer between the mains/line outlet and power plug of the HM 103-2. Without an isolating transformer, the instrument's power cable must be plugged into an approved three-contact electrical outlet, which meets International Electrotechnical Commission (IEC) safety standards.

### **Warning!**

**Any interruption of the protective conductor inside or outside the instrument or disconnection of the protective earth terminal is likely to make the instrument dangerous. Intentional interruption is prohibited.**

**If a protective isolating transformer is used for the display of signals with high zero potential, it should be noted that these voltages are also connected to the oscilloscope's case and other accessible metal parts. Voltages up to 42V are not dangerous. Higher voltages, however, involve a shock hazard. In this case, special safety measures must be taken and must be supervised by qualified personnel.**

As with most electron tubes, the cathode-ray tube develops X-rays. With the HM 103-2 **the dose equivalent rate falls far below the maximum permissible value of 36pA/kg.**

## **Operating Conditions**

Admissible ambient temperature range during operation: +10°C...+40°C. Admissible ambient temperature range for storage or transportation: -40°C...+70°C. If condensed water exists in the instrument it should not be turned on before acclimatization is achieved. In some cases (an extremely cold oscilloscope) about two hours should be allowed before putting the instrument into operation. The instrument should be placed in a clean and dry room. In other words, the instrument may not be put into operation in explosive, corrosive, dusty, or moist environments. The instrument may be operated in any position, however, the convection cooling must not be impaired. Therefore, when the instrument is in continuous operation it should be used in the horizontal position preferably on its tilt stand.

The instrument must be disconnected and secured against unintentional operation if there is any presumption that safe operation is not possible. This supposition is qualified

- if the instrument has visible damage,
- if the instrument has loose parts,
- if the instrument does not function,

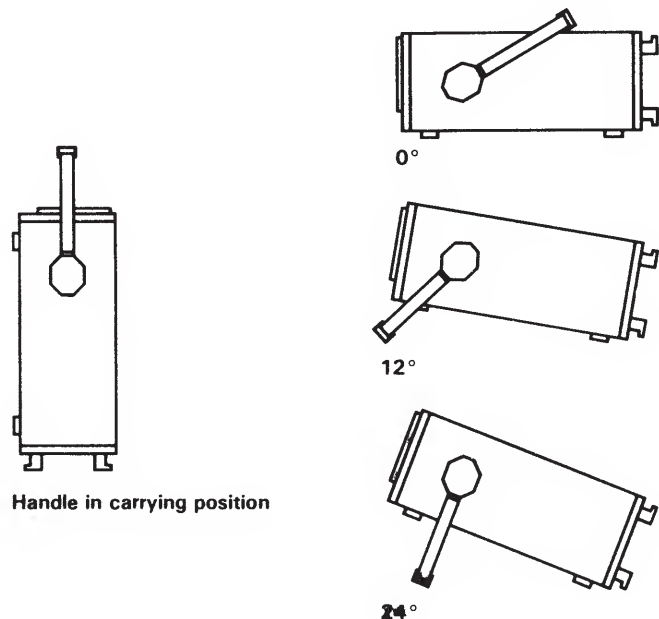
- after a long storage under unfavourable circumstances (e. g. out of doors or in moist environments),
- after excessive transportation stress (e. g. in poor packaging).

## **Use of the Tilt Handle**

The handle of the oscilloscope can be fixed in three positions, one for use as a carrying handle and two positions as a tilt stand. With the tilt handle the instrument can be inclined 12° or 24° to the horizontal.

Handling is as follows:

- Place the HM 103-2 on its rear feet. The front drop-in pins in the hinges will fall back into the front groove of the notched discs (fixed on the cabinet).
- Pull the handle only about 5mm out of its locking position and turn it towards the lower edge of the front panel.
- Lock the handle into the required position by pushing it back towards the hinges.
- Place the instrument in its work area.



## **First Time Operation**

**Check that the instrument is set to the correct mains/line voltage.**

On delivery, the instrument is set to AC 220V  $\pm$  10% (50-60 Hz) mains/line voltage. The power plug-in unit at the rear contains the three-pin power connector. For this a three wire power cord with triple-contact connector and three-pole power plug is required. The appliance inlet also contains the power fuse, which is interchangeable for the different mains/line voltages. The fuse holder with its square top

plate can be pulled out, and **changing of the mains/line voltage** is possible by turning this plate 90 degrees for each of the four voltages marked on the plate. The fuse holder should then be plugged in again in the desired position (see triangle), which should be the **closest value of the measured mains/line voltage in our area**. The set value is always readable. The power fuse must correspond to the voltage selected and when necessary should be replaced. The type and rated current are given on the rear panel and in the Service Instructions.

**Before applying power** to the oscilloscope, it is recommended that the following simple procedures are performed:

- Check that all pushbuttons are in the **out** position, i.e. released.
- Rotate the two variable controls with arrows, i.e. **TIMEBASE** variable control and **Y-AMPL.** attenuator variable control, fully clockwise in their calibrated detent.
- Set the control knobs with marker lines to their midrange position (marker lines pointing vertically).
- The **AT/NORM.** pushbutton in the X-Section should be in out position (**AT**).
- The **GD** button in the Y-Section should be depressed.

Switch on the oscilloscope by depressing the red **POWER** pushbutton. An LED will illuminate to indicate the working order. The trace, displaying a baseline, should be visible after a short warm-up period of 30 seconds. Adjust **Y-POS.** and **X-POS.** controls to center the baseline. Adjust **INTENS.** (intensity) and **FOCUS** controls for medium brightness and optimum sharpness of the trace. The oscilloscope is now ready for use.

If only a spot appears (**CAUTION!** CRT phosphor can be damaged.), reduce the intensity immediately and check that the **X-Y** pushbutton is in the released (out) position. If the trace is not visible, check the correct positions of all knobs and switches (particularly **AT/NORM.** button in out position).

To obtain the maximum life from the cathode-ray tube, the minimum intensity setting necessary for the measurement in hand and the ambient light conditions should be used. **Particular care is required when a single spot is displayed**, as a very high intensity setting may cause damage to the fluorescent screen of the CRT. Switching the oscilloscope off and on at short intervals stresses the cathode of the CRT and should therefore be avoided.

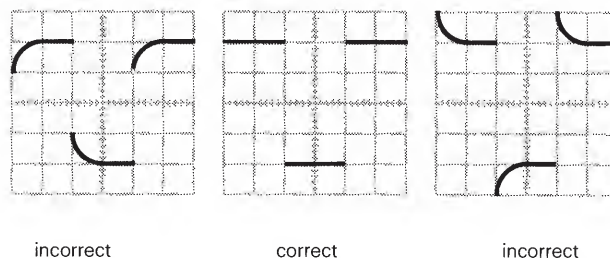
**In spite of Mumetal-shielding of the CRT, effects of the earth's magnetic field on the horizontal trace position cannot be completely avoided. This is dependent upon**

**the orientation of the oscilloscope on the place of work. A centered trace may not align exactly with the horizontal center line of the graticule. A few degrees of misalignment can be corrected by a potentiometer accessible through an opening on the front panel marked TR.**

## Probe Adjustment

To achieve the undistorted display of signals when using an x10 or x100 attenuator probe, the probe must be compensated to match the input impedance of the vertical amplifier. This can be easily achieved as the HM 103-2 has a built-in square-wave generator with a repetition frequency of approx. 1 kHz and an **output voltage of  $0.2 V_{pp} \pm 1\%$** .

The method employed is as follows. The probe tip with its sprung hook is connected to the output eyelet designated by **CAL.** (calibrator) on the front panel of the instrument. The **probe trimmer** is then adjusted by using the trimming tool supplied. The correct display is shown in the following figure.



The **TIMEBASE** switch should be in the **0.2ms/div.** position. The input coupling is set to **DC (AC/DC** button depressed). If the attenuator sensitivity is set to **5mV/div.** (variable control to **CAL.**), the display will have a height of **4div.** when a **x10** probe is being compensated. As an attenuator probe is constantly subjected to considerable stresses, the compensation should be frequently checked.

It should be noted that the frequency of the square-wave generator is unsuitable for the time calibration. Furthermore, the pulse duty factor has not the 1:1 value. Finally, the rise and fall times of the square signal are so fast that the edges – even with maximum intensity – are visible only with difficulty. This is not a flaw, but actually the precondition for a simple and exact probe compensation (or a deflection coefficient check) like horizontal pulse tops, calibrated pulse amplitude, and zero potential on the negative pulse top.

## Type of Signal

All types of signals whose frequency spectrum is below 10MHz can be displayed on the HM103-2. The display of simple electrical processes such as sinusoidal RF and AF signals or ripple poses no problems. However, when square or pulse-shaped signals are displayed, it must be remembered that their **harmonic content** must also be transmitted. In this case, the bandwidth on the vertical amplifier must be considerably higher than the repetition frequency of the signal. In view of this, accurate evaluation of such signals with the HM103-2 is only possible up to a maximum repetition rate of 1 MHz. Operating problems can sometimes occur when composite signals are to be displayed, especially if they do not contain any suitable level components and repetition frequency which can be used for triggering. This occurs, for example, with burst signals. To obtain a stably triggered display in these cases, it may be necessary to use Normal Triggering and/or **TIMEBASE** variable control. **Television video signals are relatively easy to trigger.** However, when investigating signals at **frame rate**, the **TV** pushbutton in the X-Section has to be depressed (low-pass filter). In this mode, the more rapid line pulses are attenuated so that, with appropriate level adjustment, triggering can easily be carried out on the leading or trailing edge of the frame synchronizing pulse.

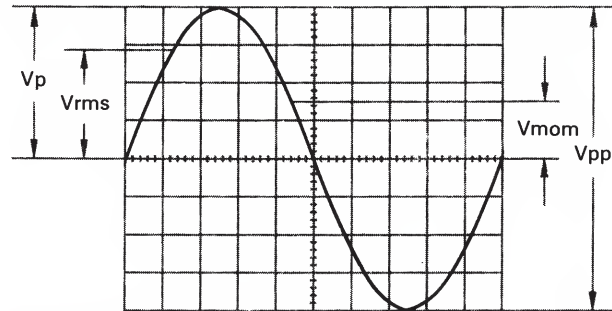
For optional operation as a DC or AC voltage amplifier, the vertical input is provided with an **AC/DC** coupling switch. The **DC** position should only be used with an attenuator probe or at very low frequencies or if the determination of DC voltage content of the signal is absolutely necessary.

However, when investigating very low-frequency pulses, misleading ramp-offs may occur with **AC** coupling. In this case, **DC** operation is to be preferred if the signal voltage is not superimposed on a too high DC voltage level. Otherwise, a capacitor of adequate capacitance must be connected before the input of the vertical amplifier (switched to **DC** coupling). It should be remembered that this capacitor must have a sufficiently high breakdown voltage. **DC** operation is also recommended for the display of logic and pulse signals, particularly if their pulse duty factor changes permanently during operation. Otherwise, the display will move up and down with any change. DC voltages can only be measured in the **DC** position.

## Amplitude Measurements

In general electrical engineering, alternating voltage data normally refers to effective values (rms = root-mean-square value). However, for signal magnitudes and voltage designations in oscilloscope measurements, the peak-to-peak voltage ( $V_{pp}$ ) value is applied. The latter corresponds to the real potential difference between the most positive and most negative points of the signal waveform.

If a sinusoidal waveform, displayed on the oscilloscope screen, is to be converted into an effective (rms) value, the resulting peak-to-peak value must be divided by  $2 \times \sqrt{2} = 2.83$ . Conversely, it should be observed that sinusoidal voltages indicated in  $V_{rms}$  ( $V_{eff}$ ) have 2.83 times the potential difference in  $V_{pp}$ . The relationship between the different voltage magnitudes can be seen from the following figure.



**Voltage values of a sine curve**

$V_{rms}$  = effective value;  $V_p$  = simple peak or crest value;  
 $V_{pp}$  = peak-to-peak value;  $V_{mom}$  = momentary value.

The minimum signal voltage required at the vertical amplifier input for a display of 1 div. is **1mV<sub>pp</sub>**. This is achieved with the **Y-AMPL.** attenuator control set at **5mV/div.**, and its **variable control in the fully clockwise position**, and the **Y-MAG. x5** pushbutton depressed (in). However, smaller signals than this may also be displayed. The **deflection coefficients** on the input attenuators are indicated in **mV/div.** or **V/div.** (peak-to-peak value).

**For exact amplitude measurements the variable control on the attenuator switch must be set to its calibrated detent CAL.**

**The magnitude of the applied voltage is ascertained by multiplying the selected deflection coefficient by the vertical display height in div.**

**If an attenuator probe x10 is used, a further multiplication by a factor of 10 is required to ascertain the correct voltage value.**

With direct connection to the vertical input, signals up to  $100V_{pp}$  may be displayed.

With the designations

**H** = display height in div.,

**U** = signal voltage in  $V_{pp}$  at the vertical input,

**D** = deflection coefficient in V/div. at attenuator switch, the required quantity can be calculated from the two given quantities:

$$U = D \cdot H$$

$$H = \frac{U}{D}$$

$$D = \frac{U}{H}$$



However, these three values are not freely selectable. They have to be within the following limits (trigger threshold, accuracy of reading):

**H** between 0.3 and 8 div., if possible 2.5 to 6 div.,

**U** between  $1.5V_{pp}$  and  $40V_{pp}$ ,

**D** between 5 mV/div. and 5 V/div. in 1-2-5 sequence.

#### Examples:

Set deflection coefficient **D** = 50 mV/div.  $\triangleq$  0.05 V/div.,  
observed display height **H** = 4.6 div.,

**required voltage U** =  $0.05 \cdot 4.6 = 0.23 V_{pp}$ .

Input voltage **U** =  $5V_{pp}$ ,

set deflection coefficient **D** = 1 V/div.,

**required display height H** =  $5:1 = 5 \text{ div.}$

Signal voltage **U** =  $220V_{rms} \cdot 2 \cdot \sqrt{2} = 622 V_{pp}$

(voltage  $> 40V_{pp}$ , with probe  $\times 100$ : **U** =  $6.22 V_{pp}$ ),

desired display height **H** = min. 3.2 div., max. 8 div.,

max. deflection coefficient **D** =  $6.22 : 3.2 = 1.94 \text{ V/div.}$ ,

min. deflection coefficient **D** =  $6.22 : 8 = 0.78 \text{ V/div.}$ ,

**adjusted deflection coefficient D** = 1 V/div.

**If the applied signal is superimposed on a DC (direct voltage) level the total value (DC + peak value of the alternating voltage) of the signal across the Y-input must not exceed  $\pm 400V$ .** This same limit applies to normal attenuator probes  $\times 10$ , the attenuation ratio of which allows signal voltages up to approximately 600V (DC +  $AC_{peak}$ ) to be evaluated. Voltages of up to approximately 1,200V (DC +  $AC_{peak}$ ) may be measured by using the HZ53 high voltage probe which has an attenuation ratio of 100:1. It should be noted that its  $V_{rms}$  value is derated at higher frequencies (see page M6: Connection of Test Signal). If a normal  $\times 10$  probe is used to measure high voltages there is the risk that the compensation trimmer bridging the attenuator series resistor will break down causing damage to the input of the oscilloscope. However, if for example only the residual ripple of a high voltage is to be displayed on the oscilloscope, a normal  $\times 10$  probe is sufficient. In this case, an appropriate high voltage capacitor (approx. 22-68 nF) must be connected in series with the input tip of the probe.

It is very important that the oscilloscope input coupling is set to **DC**, if an attenuator probe is used for voltages higher than 400V (see page M6: Connection of Test Signal).

With input coupling switched to **GD** and with the **Y-POS.** control, a horizontal graticule line can be adjusted as a **reference axis for ground potential**. It can be placed underneath, on, or above the horizontal center line, as the case may be to measure positive and/or negative deviations from ground potential. Some switchable probes have a built-in reference switch position for the same application.

## Time Measurements

As a rule, all signals to be displayed are periodically repeating processes and can also be designated as periods. The number of periods per second is the recurrence frequency or repetition rate. One or more signal periods or even part of a period may be shown as a function of the adjustment of the **TIMEBASE** switch. The time coefficients on the **TIMEBASE** switch are indicated in **ms/div.** and  **$\mu\text{s/div.}$** . Accordingly, the dial is subdivided into two sectors.

**The duration of a signal period or a portion of the waveform is ascertained by multiplying the relevant time (horizontal distance in div.) by the time coefficient selected on the TIMEBASE switch.**

**The time variable control (small knob on the TIMEBASE switch) must be in its calibrated detent (CAL.) for accurate measurement** (arrow horizontal and pointing to the right).

With the designations

**L** = displayed wave **length in div.** of one period,

**T** = **time in seconds** for one period,

**F** = recurrence **frequency in Hz** of the signal,

**T<sub>c</sub>** = **time coefficient in s/div.** on timebase switch

and the relation **F** =  $1/T$ , the following equations can be stated:

$$\begin{aligned} T &= L \cdot T_c & L &= \frac{T}{T_c} & T_c &= \frac{T}{L} \\ F &= \frac{1}{L \cdot T_c} & L &= \frac{1}{F \cdot T_c} & T_c &= \frac{1}{L \cdot F} \end{aligned}$$

**However, these four values are not freely selectable.**

**They have to be within the following limits:**

**L** between 0.2 and 10 div., if possible 1 to 10 div.,

**T** between 0.1  $\mu\text{s}$  and 0.5 s,

**F** between 2 Hz and 10 MHz,

**T<sub>c</sub>** between 0.2  $\mu\text{s/div.}$  and 0.1 s/div. in 1-2-5 sequence

#### Examples:

Displayed wavelength **L** = 7 div.,

set time coefficient **T<sub>c</sub>** = 0.5  $\mu\text{s/div.}$ ,

**required period T** =  $7 \cdot 0.5 \cdot 10^{-6} = 3.5 \mu\text{s}$

**required rec. freq. F** =  $1 : (3.5 \cdot 10^{-6}) = 286 \text{ kHz.}$

Signal period **T** = 0.5 s,

set time coefficient **T<sub>c</sub>** = 0.1 s/div.,

**required wavelength L** =  $0.5 : 0.1 = 5 \text{ div.}$

Displayed ripple wavelength **L** = 1 div.,

set time coefficient **T<sub>c</sub>** = 10 ms/div.,

**required ripple freq. F** =  $1 : (1 \cdot 10 \cdot 10^{-3}) = 100 \text{ Hz.}$

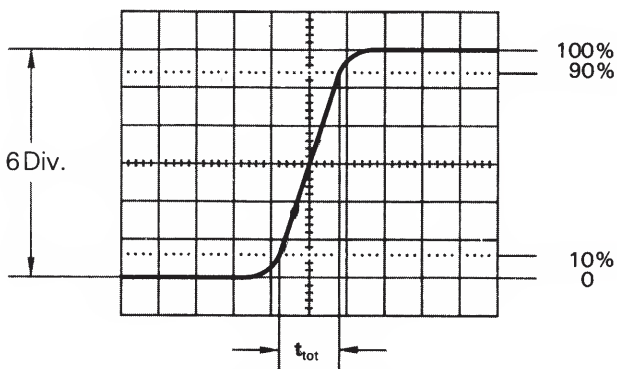
TV-line frequency  $F = 15\,625\text{ Hz}$ ,  
 set time coefficient  $T_c = 10\,\mu\text{s/div.}$ ,  
**required wavelength  $L = 1:(15\,625 \cdot 10^{-5}) = 6.4\text{ div.}$**

Sine wavelength  $L = \text{min. } 2.8\text{ div.}, \text{ max. } 7\text{ div.}$ ,  
 Frequency  $F = 1\text{ kHz}$ ,  
 max. time coefficient  $T_c = 1:(2.8 \cdot 10^3) = 0.357\text{ ms/div.}$ ,  
 min. time coefficient  $T_c = 1:(7 \cdot 10^3) = 0.143\text{ ms/div.}$ ,  
**set time coefficient  $T_c = 0.2\text{ ms/div.}$** ,  
**required wavelength  $L = 1:(10^3 \cdot 0.2 \cdot 10^{-3}) = 5\text{ div.}$**

When investigating pulse or square waveforms, the critical feature is the **risetime of the voltage step**. To ensure that transients, ramp-offs, and bandwidth limits do not unduly influence the measuring accuracy, the risetime is generally measured between **10%** and **90%** of the vertical pulse height.

**Example:** A peak-to-peak pulse amplitude of **5 div. vertical height** is symmetrically adjusted to the horizontal center line using the **Y-AMPL.** switch and its variable control and **Y-POS.** control. Use a sweep speed setting that displays one or max. three cycles (if possible) and be sure the **TIMEBASE** variable control is in the calibrated detent. The desired rising edge of the signal now intersects both the  $-2\text{ div.}$  (10%) and the  $+2\text{ div.}$  (90%) horizontal graticule line. **Measure the horizontal distance in div. between the 10% and 90% points and multiply this distance by the setting of the time coefficient on the TIMEBASE switch.** Similarly, the falltime is measured between the 90% and 10% points on the trailing edge of the waveform.

The following figure shows correct positioning of the oscilloscope trace for accurate risetime measurement.



With a set time coefficient on the TIMEBASE switch of  $20\,\mu\text{s/div.}$ , the example in the above figure would result in a measured total risetime of

$$t_{\text{tot}} = 1.6\text{ div.} \cdot 20\,\mu\text{s/div.} = 32\,\mu\text{s}$$

The above is, of course, only an example, as different settings for the displayed pulse amplitude are possible. Note: All settings in the Y-Section do not affect the time measure-

ment. It is only important that the horizontal time distance is measured between 10% and 90% of the pulse height and that the time variable control is in the calibrated **CAL.** position. For accuracy reasons, the display height should not be too steep (too small sweep speed).

When very fast risetimes are being measured, the risetime of the oscilloscope amplifier has to be deducted from the measured time value. The risetime of the signal can be calculated using the following formula.

$$t_r = \sqrt{t_{\text{tot}}^2 - t_{\text{osc}}^2}$$

In this  $t_{\text{tot}}$  is the total measured risetime,  $t_{\text{osc}}$  is the risetime of the oscilloscope amplifier (approx. 35 ns with HM 103-2). If  $t_{\text{tot}}$  is greater than 250 ns, then  $t_{\text{tot}}$  can be taken as the risetime of the pulse, and calculation is unnecessary (error smaller than 1%).

## Connection of Test Signal

The signal to be displayed should be fed to the vertical input of the oscilloscope by means of a shielded test cable, e.g. the HZ32 or HZ34, or by a  $\times 10$  or  $\times 100$  attenuator probe. The use of these shielded cables with high impedance circuits is only recommended for relatively low frequencies (up to approx. 50 kHz). for higher frequencies, and when the signal source is of low impedance, a cable of matched characteristic impedance (usually  $50\,\Omega$ ) is recommended.

**In addition, and especially when investigating square or pulse waveforms, a resistor equivalent to the characteristic impedance of the cable must also be connected to the cable directly at the input of the oscilloscope.**

When using a  $50\,\Omega$  cable, such as the HZ34, a  $50\,\Omega$  through-termination type HZ22 is available from HAMEG. When investigating square or pulse waveforms with fast risetimes, transient phenomena on both the edge and top of the signal may become visible if the correct termination is not used. It must be remembered that the  $50\,\Omega$  through-termination will only dissipate a maximum of 2 watts. This power consumption is reached with  $10V_{\text{rms}}$  or with  $28V_{\text{pp}}$  sine signal. If a  $\times 10$  attenuator probe (e.g. HZ36) is used, no termination is necessary. In this case, the connecting cable is matched directly to the high impedance input of the oscilloscope. When using attenuator probes, even high internal impedance sources are only slightly loaded (by approximately  $10\text{ M}\Omega \parallel 12\text{ pF}$ ). Therefore, when the voltage loss due to the attenuation of the probe can be compensated by a higher sensitivity setting on the HM 103-2, the probe should always be used. Also it should be remembered that the series impedance of the probe provides a certain amount of protection for the input of the oscilloscope amplifier. It should be noted that all attenuator probes must be compensated in conjunction with the oscilloscope (see: Probe Adjustment, page M3).

**If a x10 or x100 attenuator probe is used, the DC input coupling must always be set.** With **AC** coupling, the attenuation is frequency-dependent, the pulses displayed can exhibit ramp-off, DC-voltage contents are suppressed – but loads the respective input coupling capacitor of the oscilloscope. The electric strength of which is maximum 400V (DC + peak AC). For the suppression of unwanted DC voltages, a **capacitor** of adequate capacitance and electric strength **may be connected before the input tip of the probe** (e.g. for ripple measurements).

With the HZ53 x100 probe, the permissible AC input voltage is frequency-dependent limited:

**below 20kHz** (TV line frequency!) up to

$$\text{max. } 1,200 V_p \triangleq 2,400 V_{pp} \triangleq 851 V_{rms};$$

**above 20kHz** (with f in MHz) up to

$$\frac{212}{\sqrt{f}} V_p \triangleq \frac{424}{\sqrt{f}} V_{pp} \triangleq \frac{150}{\sqrt{f}} V_{rms}.$$

It is important to remember that when low voltage signals are being investigated the position of the ground point on the test circuit can be critical. This ground point should always be located as close as possible to the measuring point. If this is not done, serious signal deformation may result from any spurious currents through the ground leads or test chassis parts. This comment also applies to the ground leads on attenuator probes which ideally should be as short and as thick as possible. For connection of a probe to a BNC socket, a BNC-adaptor should be used. It forms often a part of the probe accessory. Grounding and matching problems are then eliminated.

The location and quantitative measurement of a magnetic leakage (e.g. from power transformer) into a circuit is possible using a pick-up coil. If the coil has many windings, it should be shielded against static fields (non-magnetic shield without short-circuited turn). Also the interconnection between coil and oscilloscope vertical input should be made by a shielded cable with BNC male connector at one end. A resistor of approx. 100Ω should be connected in series between cable core and connector core. This resistor attenuates radio-frequency excitation. The shieldings prevent any undesired capacitive couplings.

Hum or interference voltage appearing in the measuring circuit (especially with a small deflection coefficient) is possibly caused by multiple grounding, because equalizing currents can flow in the shielding of the measuring cables (voltage drop between non-fused earthed conductors of other line powered devices, which are connected to the oscilloscope or test object, e.g. signal generators with anti-interference capacitors).

Sometimes the trace will disappear after an input signal has been applied. The attenuator switch must then be turned back to the left, until the vertical signal height is only 2.4-6div. with a signal amplitude greater than 40V<sub>pp</sub>, an attenuator probe must be inserted before the oscilloscope's vertical input, if, after applying the signal, the trace is nearly blanked, the period of the signal is probably substantially longer than the set value on the **TIMEBASE** switch. It should be turned to the left on an adequately greater time coefficient.

**Caution:** When connecting unknown signals to the oscilloscope input, always use Automatic Triggering and set the **AC/DC** input coupling to **AC**. The **Y-AMPL.** attenuator switch should initially be set to **5V/div.**

## Triggering and Timebase

In order to obtain a satisfactory stable display, the timebase must be triggered synchronously with the test signal. The trigger signal can be derived from the test signal itself, when internal triggering is selected, or from a frequency related signal applied to the external trigger input. **Note that the trigger voltage is always AC coupled.**

**If the AT/NORM. pushbutton in the X-Section is in the out position AT (Automatic Triggering),** the sweep generator will be triggered automatically. In the **AT** position and with proper trigger control settings, the sweep can be started by virtually all uncomplicated signals with repetition rates above about 30Hz and within the frequency range selected by the trigger coupling switch, provided that the displayed signal height is at least **0.5div.** (trigger threshold for internal triggering). In the absence of an adequate trigger signal or when the trigger controls are misadjusted, the sweep free-runs and produces a baseline (time axis) as a reference trace. **Automatic Triggering takes place without operating the LEVEL control.** The trigger mode operates in principle also with external triggering via the **TRIG. EXT.** connector. However, the (synchronous) trigger voltage required for it should be approximately in the 0.4-4V<sub>pp</sub> range.

With **Normal Triggering (AT/NORM. button depressed)** and **LEVEL** adjustment, the sweep can be started by signals within the frequency range from 2Hz up to 30MHz. In the absence of an adequate trigger signal or when the trigger controls (particularly the **LEVEL** control) are misadjusted, no trace is visible, i.e. the screen is blanked completely. When using the internal Normal Triggering mode, it is possible to trigger at any amplitude point of a signal edge, even with very complex signal shapes, by adjusting the **LEVEL** control. Its adjusting range is directly dependent on the display height, which should be at least **0.5div.** If it is smaller than 1 div, the **LEVEL** adjustment needs to be oper-



ated with a sensitive touch. In the external Normal Triggering mode, the same applies to the external trigger voltage amplitude.

Triggering can be selected on either the rising or falling edge of the trigger signal depending on whether the **+/- slope** pushbutton is in the out or in position. In the out position, triggering from the positive-going edge is selected. The correct slope setting is important in obtaining a display when only a portion of a cycle is being displayed.

For **external triggering**, the **TRIG. EXT.** pushbutton in the X-Section must be depressed. The sync. signal (**0.4-4 V<sub>pp</sub>**) must then be fed to the **TRIG. EXT.** input connector.

In the **TV coupling mode**, a **low-pass filter** is switched into the trigger circuit. This filter cuts off any amplifier noise and the frequency range above 1 kHz of the trigger signal.

If the **video signal** of a television set is to be displayed at **frame frequency**, triggering is generally difficult due to the presence of the higher line frequency pulses can be attenuated by depressing the **TV** pushbutton in the X-Section. With **Normal Triggering** and correct setting of the **+/- slope** button, it will now be found that the trigger **LEVEL** control can be adjusted to trigger from either the leading or trailing edge of the frame pulse. This setting is advantageous for triggering from other signals that have a recurrence frequency of 800 Hz or less, as high frequency harmonics or noise in the signal are suppressed by the presence of the low-pass filter. However, **TV triggering at line frequency** needs **AC** coupling (**TV** button in out position). In both cases, always **Normal Triggering** with **LEVEL** adjustment should be used.

As already mentioned, simple signals may be triggered automatically in the automatic trigger mode (**AT/NORM.** button in out position). The repetition rate may also vary in such cases. However, if the pulse duty factor on square-wave or pulse signals changes drastically or deforms to a needle pulse, the **Normal Triggering** mode with **LEVEL** adjustment may well become necessary. With composite signals, the trigger facility is dependent on the occurrence of certain periodically recurring levels. The **LEVEL** adjustment of these signals will require some care.

If it is found that a trigger point cannot be located on extremely complex signals even after repeated and careful adjustment of the **LEVEL** control in the **Normal Triggering** mode, a stable display may be obtained using the **TIMEBASE** variable control.

The time coefficient settings on the **TIMEBASE** switch are calibrated when the variable control (small knob on the **TIMEBASE** switch) is set in the **CAL.** position. When this

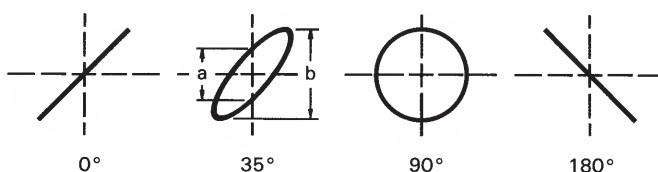
control is set fully counter clockwise, the sweep speed is decreased by a factor of at least 2.5. This factor is not precisely calibrated. When both the **TIMEBASE** switch and its variable control are set fully counter clockwise, a minimum sweep rate of approximately **0.25 s/div.** is obtained. The choice of the optimum time coefficient depends on the repetition rate of the signal being measured. The number of cycles displayed will increase with the time coefficient (by turning the **TIMEBASE** switch counterclockwise).

## X-Y Operation

For X-Y operation, the **HOR. EXT.** pushbutton has to be depressed. The X signal must then be fed to the **HOR. EXT.** input. The sensitivity of the X amplifier is not adjustable. It is approximately 0.45 V<sub>pp</sub>/div. Therefore, the maximum permissible voltage on this connector should not exceed 4.5 V<sub>pp</sub>. Higher voltages should be attenuated before connecting. The horizontal input is capacitively coupled; therefore, only AC voltages can be used for external horizontal deflection. The bandwidth of the X amplifier ranges from 2 Hz to 850 kHz (-3 dB). It should be noted that there is an increase in phase difference between X and Y above 20 kHz, which exceeds 3° at approx. 70 kHz.

If the voltages applied to the X and Y input connectors fail, a bright spot is displayed on the screen. With too high intensity setting, this spot may cause phosphor burning, giving a permanent loss of efficiency or, in extreme cases, complete damage of the phosphor at this point.

In the X-Y operation mode, Lissajous figures can be used for phase comparison between two signals of the same frequency or for comparison of two signals with different frequencies.



### Examples of Lissajous figures:

Two sine signals of the same frequency (and amplitude) with different phase angles.

Calculation of the phase angle (independent of both deflection amplitudes)

$$\sin \varphi = \frac{a}{b}$$

$$\cos \varphi = \sqrt{1 - \left(\frac{a}{b}\right)^2}$$

$$\varphi = \arcsin \frac{a}{b}$$



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## Component Tester

### General

The HM 103-2 has a built-in electronic Component Tester (abbreviated **CT**), which is used for instant display of a test pattern to indicate whether or not components are faulty. The **CT** can be used for quick checks of semiconductors (e.g. diodes and transistors), resistors, capacitors, and inductors. Certain tests can also be made to integrated circuits. All these components can be tested in and out of circuit.

The test principle is fascinatingly simple. The power transformer of the HM 103-2 delivers a sine voltage, which is applied across the component under test and a built-in fixed resistor. The sine voltage across the test object is used for the horizontal deflection, and the voltage drop across the resistor (i.e. current through test object) is used for vertical deflection of the oscilloscope. The test pattern shows a current-voltage characteristic of the test object.

Since this circuit operates with mains/line frequency (50 or 60 Hz) and a voltage of 8.5 V max. (open circuit), the indicating range of the **CT** is limited. The impedance of the component under test is limited to a range from 20  $\Omega$  to 4.7 k $\Omega$ . Below and above these values, the test pattern shows only short-circuit or open-circuit. For the interpretation of the displayed test pattern, these limits should always be borne in mind. However, most electronic components can normally be tested without any restriction.

### Using the Component Tester

The **CT** is switched on by depressing the **CT** pushbutton in the Y-Section. This makes the vertical preamplifier and the timebase generator inoperative. A shortened horizontal trace will be observed. It is not necessary to disconnect scope input cables unless in-circuit measurements are to be carried out. In the **CT** mode, the only controls which can be operated are **INTENS.**, **FOCUS**, and **X-POS.**. All other controls and settings have no influence on the test operation.

For the component connection, two simple test leads with 4 mm  $\varnothing$  banana plugs, and with test prod, alligator clip or sprung hook, are required. The test leads are connected to the insulated **CT** socket and the adjacent ground socket in the Y-Section. The component can be connected to the test leads either way round.

After use, to return the oscilloscope to normal operation, release the **CT** pushbutton.

### Test Procedure

**Caution! Do not test any component in live circuitry – remove all grounds, power and signals connected to the component under test. Set up Component Tester as stated above. Connect test leads across component to be tested. Observe oscilloscope display.**

### Test Pattern Displays

Page M 11 shows typical test patterns displayed by the various components under test.

- **Open circuit is indicated by a straight horizontal line.**
- **Short circuit is shown by a straight vertical line.**

### Testing Resistors

If the test object has a linear ohmic resistance, both deflecting voltages are in the same phase. The test pattern expected from a resistor is therefore a sloping straight line. The angle of slope is determined by the resistance of the resistor under test. With high values of resistance, the slope will tend towards the horizontal axis, and with low values, the slope will move towards the vertical axis.

Values of resistance from 20  $\Omega$  to 4.7 k $\Omega$  can be approximately evaluated. The determination of actual values will come with experience, or by direct comparison with a component of a known value.

### Testing Capacitors and Inductors

Capacitors and inductors cause a phase difference between current and voltage, and therefore between the X and Y deflection, giving an ellipse-shaped display. The position and opening width of the ellipse will vary according to the impedance value (at 50 or 60 Hz) of the component under test.

**A horizontal ellipse indicates a high impedance or a relatively small capacitance or a relatively high inductance.**

**A vertical ellipse indicates a small impedance or a relatively large capacitance or a relatively small inductance.**

**A sloping ellipse means that the component has a considerable ohmic resistance in addition to its reactance.**

The values of capacitance of normal or electrolytic capacitors from 0.1  $\mu$ F to 1000  $\mu$ F can be displayed and approximate values obtained. More precise measurement can be obtained in a smaller range by comparing the capacitor under test with a capacitor of known value. Inductive components (coils, transformers) can also be tested. The determination of the value of inductance needs some experience, because inductors have usually a higher ohmic series resistance. However, the impedance value (at 50 or 60 Hz) of an inductor in the range from 20  $\Omega$  to 4.7 k $\Omega$  can easily be obtained or compared.

### Testing Semiconductors

Most semiconductor devices, such as diodes, Z-diodes, transistors, FETs can be tested. The test pattern displays vary according to the component type as shown in the figures below.

The main characteristic displayed during semiconductor testing is the voltage dependent knee caused by the junction changing from the conducting state to the non conducting state. It should be noted that both the forward and the reverse characteristic are displayed simultaneously. This is always a two-terminal test, therefore testing of transistor amplification is not possible, but testing of a single junction is easily and quickly possible. Since the **CT** test voltage applied is only very low (max. 8.5 V<sub>rms</sub>), all sections of most semiconductors can be tested without damage. However, checking the breakdown or reverse voltage of high voltage semiconductors is not possible. More important is testing components for open or short-circuit, which from experience is most frequently needed.

## Testing Diodes

Diodes normally show at least their knee in the forward characteristic. This is not valid for some high voltage diode types, because they contain a series connection of several diodes. Possibly only a small portion of the knee is visible. Z-diodes always show their forward knee and, up to approx. 10V, their Z-breakdown, forms a second knee in the opposite direction. A Z-breakdown voltage of more than 12V can not be displayed.



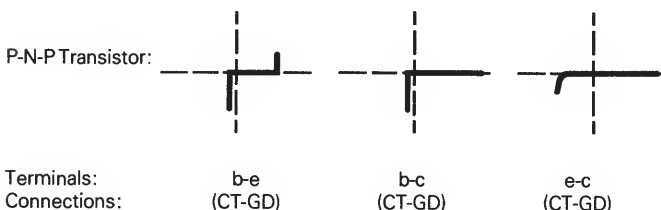
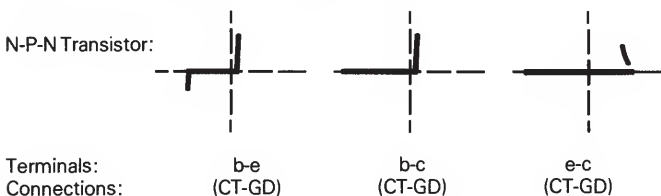
Type:	Normal Diode	High Voltage Diode	Z-Diode 12V
Terminals:	Cathode-Anode	Cathode-Anode	Cathode-Anode
Connections:	(CT-GD)	(CT-GD)	(CT-GD)

The polarity of an unknown diode can be identified by comparison with a known diode.

## Testing Transistors

Three different tests can be made to transistors: base-emitter, base-collector and emitter-collector. The resulting test patterns are shown below.

The basic equivalent circuit of a transistor is a Z-diode between base and emitter and a normal diode with reverse polarity between base and collector in series connection. There are three different test patterns:



For a transistor the figures b-e and b-c are important. The figure e-c can vary; but a vertical line only shows short circuit condition.

These transistor test patterns are valid in most cases, but there are exceptions to the rule (e.g. Darlington, FETs). With the **CT**, the distinction between a P-N-P to a N-P-N transistor is discernible. In case of doubt, comparison with a known type is helpful. It should be noted that the same socket connection (**CT** or ground) for the same terminal is then absolutely necessary. A connection inversion effects a rotation of the test pattern by 180 degrees round about the center point of the scope graticule.

**Pay attention to the usual caution with single MOS-components relating to static charge or frictional electricity!**

## In-Circuit Tests

**Caution! During in-circuit tests make sure the circuit is dead. No power from mains/line or battery and no signal inputs are permitted. Remove all ground connections including Safety Earth (pull out power plug from outlet). Remove all measuring cables including probes between oscilloscope and circuit under test. Otherwise the connection of both CT test leads is not recommended.**

In-circuit tests are possible in many cases. However, they are not so well-defined. This is caused by a shunt connection of real or complex impedances – especially if they are of relatively low impedance at 50 or 60Hz – to the component under test, often results differ greatly when compared with single components. In case of doubt, one component terminal may be unsoldered. This terminal should then be connected to the insulated **CT** socket avoiding hum distortion of the test pattern.

Another way is a test pattern comparison to an identical circuit which is known to be operational (likewise without power and any external connections). Using the test prods, identical test points in each circuit can be checked, and a defect can be determined quickly and easily. Possibly the device itself under test contains a reference circuit (e.g. a second stereo channel, push-pull amplifier, symmetrical bridge circuit), which is not defective.

The test patterns on page M11 show some typical displays for in-circuit tests.

## Maintenance

Within the context of maintenance, it is recommended that the most important characteristics and criteria of the HM103-2 be periodically checked. The following Test Instructions indicate only those tests, which can be performed without the use of expensive ancillary instruments.

## Accessories

Each HAMEG oscilloscope is supplied with an Instruction Manual and a 10:1 divider probe. However, a wide range of accessories, which include test cables and probes, are available and should be ordered according to the particular application.

## Single Components



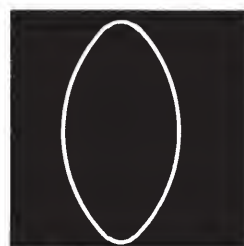
Short circuit



Resistor 510  $\Omega$



Mains transformer prim.

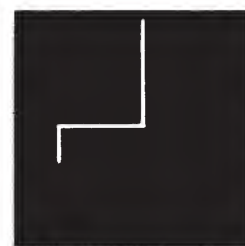


Capacitor 33  $\mu\text{F}$

## Single Transistors



Junction B-C



Junction B-E



Junction E-C



FET

## Single Diodes



Z-diode under 8 V



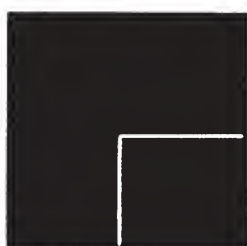
Z-diode beyond 12 V



Diode paralleled by 680  $\Omega$



2 Diodes antiparallel



Silicon diode



Germanium diode



Diode in series with 51  $\Omega$



B-E paralleled by 680  $\Omega$



Rectifier



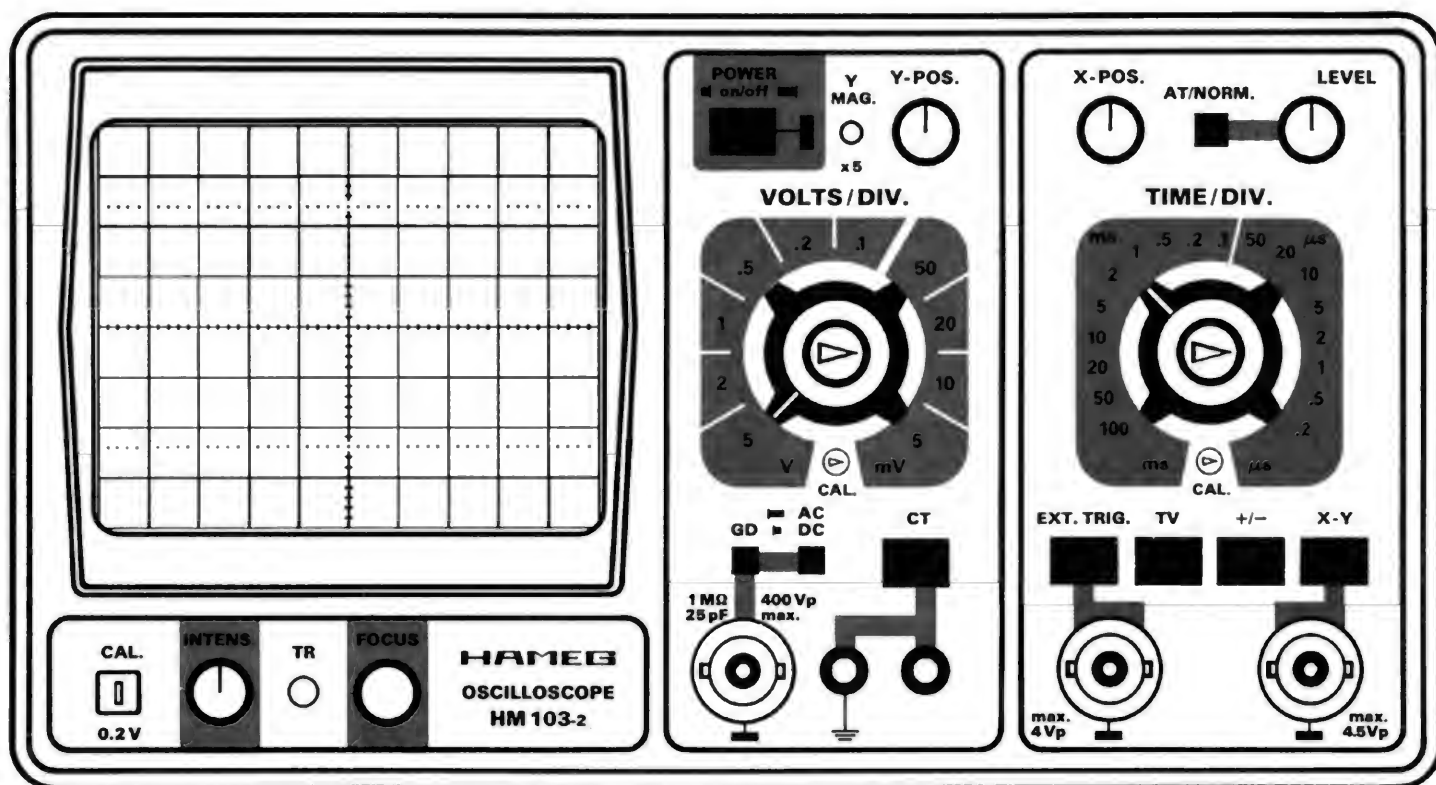
Thyristor G + A together



B-E with 1  $\mu\text{F}$  + 680  $\Omega$



Si-diode with 10  $\mu\text{F}$





## First Time Operation

Check mains/line voltage setting and fuse rating at appliance inlet on rear panel.

Connect the instrument to power outlet.

Depress **POWER** pushbutton. LED indicates operating condition.

**Case, chassis, and all measuring connectors are connected to the Safety Earth conductor (Safety Class I).**

No other button is depressed; ensure that **AT/NORM**, button in out position.

Adjust **INTENS.** control for average brightness.

Center trace on screen using **X-POS.** and **Y-POS.** controls.

Then focus trace using **FOCUS** control.

## Trigger Modes

**Automatic Triggerung: AT/NORM.** pushbutton in out position. Trace always visible.

**Normal Triggering: AT/NORM.** button depressed. Trace visible when triggered.

Normal Triggering need manual operation of the **LEVEL** control.

Triggering from positive-going signal edge: **+/- slope** button in out position.

Triggering from negative-going signal edge: **+/- slope** depressed.

This is important when only a portion of a cycle is being displayed.

Internal triggering: **TRIG. EXT.** button in out position.

External triggering: **TRIG. EXT.** button depressed. Input via **TRIG. EXT.** connector.

External trigger signal:  $0.4\text{--}4V_{pp}$ , time-related to vertical input signal.

The coupling mode for internal and external triggering is always **AC** coupled.

Composite video triggered at **frame** rate: **TV** button depressed. Use Normal Triggering.

Composite video triggered at **line** rate: **TV** button in out position. Use Normal Triggering.

## Measurement

Connect test signal to vertical input connector.

Compensate attenuator probe using **CAL.** square-wave signal.

Select **AC** or **DC** input coupling. (**GD**: Y amplifier is disconnected from input and grounded.)

Adjust required display height of signal with **Y-AMPL.** switch and variable control.

Select sweep speed with **TIMEBASE** switch and variable control.

Adjust trigger point with **LEVEL** control (only in Normal Trigger mode).

Calibrated amplitude measurement with **Y-AMPL.** The variable control must be in cal. position (**CAL.**).

Calibrated time measurement with **TIMEBASE.** The variable control must be in cal. position (**CAL.**).

**X-Y operation: HOR. EXT.** button depressed. X input via **HOR. EXT.** connector.

X deflection coefficient: approx.  $0.45V_{pp}/\text{div}$ . **AC** coupling only.

## Component Tester

Depress **CT** button. Connect component terminals to **CT** and ground jacks.

**In-circuit test:** The circuit under test must be disconnected from power, signals, and ground (earth).

Pull out power plug of the circuit under test. Remove all connections to HM 103-2 (cable, probe).

Then start testing.

# Test Instructions

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## General

These Test Instructions are intended as an aid for checking the most important characteristics of the HM 103-2 at regular intervals without the need for expensive test equipment. Resulting corrections and readjustments inside the instrument, detected by the following tests, are described in the Service Instructions or on the Adjusting Plan. They should only be undertaken by qualified personnel.

As with the First Time Operation instructions, care should be taken that all knobs with arrows are set to their calibrated positions. None of the pushbuttons should be depressed; ensure that **AT/NORM.** button is in out position, **TIME/DIV.** switch in **50 $\mu$ s/div.** and **VOLTS/DIV.** switch in **5 mV/div.** position. It is recommended to switch on the instrument for about 30 minutes prior to the commencement of any check.

## Cathode-Ray Tube: Brightness and Focus, Linearity, Raster Distortions

Normally, the CRT of the HM103-2 has very good brightness. Any reduction of this brightness can only be judged visually. However, decreased brightness may be the result of reduced high voltage. This is easily recognized by the greatly increased sensitivity of the vertical amplifier. The control range for maximum and minimum brightness (intensity) must be such that the beam just disappears before reaching the left hand stop of the **INTENS.** control (particularly when the **X-Y** button is depressed), while with the control at the right hand stop the focus and the line width are just acceptable.

***With maximum intensity the timebase fly-back must on no account be visible.***

It should be noted that with wide variations in brightness, refocusing is always necessary. Moreover, with maximum brightness, no "pumping" of the display must occur. If pumping does occur, it is normally due to a fault in the regulation circuitry for the high voltage supply. The presetting pots for the high voltage circuit, minimum and maximum intensity, are only accessible inside the instrument (see Adjusting Plan and Service Instructions).

A certain out-of-focus condition in the edge zone of the screen must be accepted. It is limited by standards of the CRT manufacturer. The same is valid for tolerances of the orthogonality, the undeflected spot position, the non-linearity and the raster distortion in the marginal zone of the screen in accordance with international standards (see CRT data book). These limit values are strictly supervised by HAMEG. The selection of a cathode-ray tube without any tolerances is practically impossible.

## Astigmatism Check

Check whether the horizontal and vertical sharpness of the display are equal. This is best seen by displaying a square-wave signal with the repetition rate of approximately 1 MHz. Focus the horizontal tops of the square-wave signal at normal intensity, then check the sharpness of the vertical edges. If it is possible to improve this vertical sharpness by turning the **FOCUS** control, then an adjustment of the astigmatism control is necessary. An alternative method is to check the shape of the spot. Depress **HOR. EXT.** button in the X-Section and depress **GD** button in the Y-Section. The **FOCUS** control is then repeatedly varied around the optimum focusing point. The shape of the spot (not its size), whether round or oval or rectangular, must stay the same to the right and left of the optimum focusing point. A potentiometer of 100k $\Omega$  (see Adjusting Plan) is provided inside the instrument for the correction of astigmatism (see Service Instructions). A certain loss of marginal sharpness of the CRT is unavoidable; this is due to the manufacturing process of the CRT.

## Symmetry and Drift of the Vertical Amplifier

Both of these characteristics are substantially determined by the input stage of the amplifiers.

***A check of the vertical amplifier symmetry is possible by shifting the Y-POS. control.*** A sine-wave signal of 10-100 kHz is applied to the amplifier input. When the **Y-POS.** control is then turned fully in both directions from stop to stop with a display height of approximately **8 div.**, the upper and lower portions of the trace that are visible should be approximately of the same height. Differences of up to 1 div. are permissible (input coupling should be set to **AC**).

Checking the drift is relatively simple. **Ten minutes after switching on the instrument**, set the baseline exactly on the horizontal center line of the graticule. The beam position must not change by more than **0.5 div.** during the following hour.

Fluctuations in drift are caused by offset current. The drift is too high, if the vertical trace position drifts by more than **0.5 div.** on turning the appropriate attenuator switch through all 10 steps. Sometimes such effects occur after long periods of operation.

## Calibration of the Vertical Amplifier

A square-wave voltage of **200 mV<sub>pp</sub>  $\pm$  1%** is present at the output eyelet. If a direct connection is made between this eyelet and the input of the vertical amplifier, the displayed signal in the **50 mV/div.** position (variable control to **CAL.**) should be **4 div.** high (**DC** input coupling). Maximum deviations of 0.12 div. (3%) are permissible. If a **x10 probe** is con-

nected between the output eyelet and Y input, the same display height should result in the **5 mV/div.** position. With higher tolerances it should first be investigated whether the cause lies, within the amplifier or in the amplitude of the square-wave signal. On occasions it is possible that the probe is faulty or incorrectly compensated. If necessary the measuring amplifier can be calibrated with an accurately known DC voltage (**DC** input coupling). The trace position should then vary in accordance with the deflection coefficient set.

With variable control at the attenuator switch fully counter clockwise, the input sensitivity is decreased at least by the factor 2.5 in each position. In the **50 mV/div.** position, the displayed calibrator signal height should vary from 4 div. to at least 1.6 div.

## Transmission Performance of the Vertical Amplifier

The transient response and the delay distortion correction can only be checked with the aid of a square-wave generator with a fast risetime (**max. 5 ns**). The signal coaxial cable (e.g. HZ34) must be terminated at the vertical input of the oscilloscope with a resistor equal to the characteristic impedance of the cable (e.g. with HZ22). Checks should be made at 50 Hz, 500 kHz, 50 kHz, 50 kHz and 500 kHz, the deflection coefficient should be set at **5 mV/div.** with **DC** input coupling (Y variable control in **CAL.** position). In so doing, the square pulses must have a flat top without ramp-off, spikes and glitches; no overshoot is permitted, especially at 500 kHz and a display height of **4-5 div.**. At the same time, the leading top corner of the pulse must not be rounded. In general, no great changes occur after the instrument has left the factory, and it is left to the operator's discretion whether this test is undertaken or not.

Of course, the quality of the transmission performance is not only dependent on the vertical amplifier. **The input attenuators**, located in the front of the amplifier, **are frequency-compensated in each position**. Even small capacitive changes can reduce the transmission performance. Faults of this kind are as a rule most easily detected with a square-wave signal with a low repetition rate (e.g. 1 kHz). If a suitable generator with max. output of 10 V<sub>pp</sub> is available, it is advisable to check at regular intervals the deflection coefficients on all positions of the input attenuators and readjust them as necessary. A compensated **2:1 series attenuator** is also necessary, and this must be matched to the input impedance of the oscilloscope.

This attenuator can be made up locally. It is important that this attenuator is shielded. For local manufacture, the electrical components required are a 1 M $\Omega$   $\pm$  1 % resistor and, in

parallel with it, a trimmer 3-15 pF in parallel with approx. 20 pF. One side of this parallel circuit is connected directly to the input connector of the vertical amplifier and the other side is connected to the generator, if possible via a low-capacitance coaxial cable. The series attenuator must be matched to the input impedance of the oscilloscope in the **5 mV/div.** position (variable control to **CAL.**, **DC** input coupling; square tops exactly horizontal; no ramp-off is permitted). This is achieved by adjusting the trimmer located in the 2:1 attenuator.

***The shape of the square-wave should then be the same in each input attenuator position.***

## Triggering Checks

The internal trigger threshold is important as it determines the display height from which a signal will be stably displayed. It should be approx. 0.5 div. (frequency-dependent) for the HM103-2. An increased trigger sensitivity creates the risk of response to the noise level in the trigger circuit, especially when the sensitivity of the vertical input is increased by pressing the **Y-MAG. x5** pushbutton. This can produce double-triggering with two out-of-phase traces. Alteration of the trigger threshold is only possible internally. Checks can be made with any **sine-wave voltage** between 50 Hz and 1 MHz. The **AT/NORM.** button should be in out position (Automatic Triggering). Following this it should be ascertained whether the same trigger sensitivity is also present with Normal Triggering (**AT/NORM.** button depressed). In this trigger mode, a **LEVEL** adjustment is necessary. The checks should show the same trigger threshold with the same frequency. On depressing the **+/-** slope button, the start of the sweep changes from the positive-going to the negative-going edge of the trigger signal. For higher frequencies, triggering up to at least 30 MHz (sinewave) should be possible.

For external triggering (**EXT. TRIG.** pushbutton depressed), the **EXT. TRIG.** input connector requires a signal voltage of at least 0.4 V<sub>pp</sub>, which is in synchronism with the Y input signal.

Checking of the internal TV triggering is possible with a video signal of any given polarity. In the **TV** position only, reliable triggering on **frame** rate is possible. However, triggering on **line** (horizontal scanning) frequency is only possible with **TV** button in out position. If no video signal is available, the function of the **TV** position (low-pass filter) can be checked using mains/line frequency or the built-in calibrator signal. With a mains/line frequency signal (50-60 Hz), depressing of the **TV** button should have no effect in contrast, the minimum signal voltage required for reliable triggering should be at least double, when the 1 kHz calibration signal is applied.



## Timebase

Before checking the timebase it should be ascertained that the **trace length is approx. 10 div.** If not, it can be corrected with the potentiometer for sweep amplitude (see Adjusting Plan). This adjustment should be made with the **TIME-BASE** switch in a mid-position (i.e. **50  $\mu$ s/div.**). Prior to the commencement of any check set the time variable control to **CAL**. This condition should be maintained until the variation ranges of these controls are checked.

Check that the **sweep runs from the left to the right side of the screen** (**TIMEBASE** switch to **100 ms/div.**; **X-POS.** control in mid-range). This check is only necessary after changing the cathode-ray tube.

If a precise marker signal is not available for checking the **Timebase** time coefficients, then an accurate sine-wave generator may be used. Its frequency tolerance should not be greater than  $\pm 1\%$ . The timebase accuracy of the HM 103-2 is given as  $\pm 5\%$ , but as a rule it is considerably better than this. For the simultaneous checking of timebase linearity and accuracy at least 10 oscillations, i.e. **1 cycle every div.**, should always be displayed. For precise determination, set the peak of the first marker or cycle peak exactly behind the first vertical graticule line using the **X-POS.** control. Deviation tendencies can be noted after some of the marker or cycle peaks.

The **20** and **10 ms/div.** ranges of the **TIMEBASE** switch can be checked very precisely with line frequency (**50 Hz** only). On the **20 ms/div.** range a cycle will be displayed every div., while on the **10 ms/div.** range it will be every 2 div.

If a precise Time Mark Generator is used for checking, Normal Triggering (**AT/NORM.** button depressed) and **LEVEL** control adjustment is recommended.

The following table shows which frequencies are required for the particular ranges.

100 ms/div. — 10 Hz	0.1 ms/div. — 10 kHz
50 ms/div. — 20 Hz	50 $\mu$ s/div. — 20 kHz
20 ms/div. — 50 Hz	20 $\mu$ s/div. — 50 kHz
10 ms/div. — 100 Hz	10 $\mu$ s/div. — 100 kHz
5 ms/div. — 200 Hz	5 $\mu$ s/div. — 200 kHz
2 ms/div. — 500 Hz	2 $\mu$ s/div. — 500 kHz
1 ms/div. — 1 kHz	1 $\mu$ s/div. — 1 MHz
0.5 ms/div. — 2 kHz	0.5 $\mu$ s/div. — 2 MHz
0.2 ms/div. — 5 kHz	0.2 $\mu$ s/div. — 5 MHz

The **time variable control** range can also be checked. The sweep speed becomes slower by turning this variable control counter clockwise to its left stop. Five cycles at least every **2 div.** should be displayed measurement in the **50  $\mu$ s/div.** range).

## X-Y Operation

The deflection coefficient of the **horizontal** amplifier is approximately  $0.45 V_{pp}/div.$  This value can be checked with the sine voltage of a 1 kHz generator. Adjust the output voltage on the generator to  $1.5 V_{rms}$ . If the generator's output voltage cannot be exactly determined, it should be measured using the vertical input of the oscilloscope and adjusted (on the generator's voltage control) to the equivalent value of about  $4.5 V_{pp}$ . Note down this value. Next, connect the generator to the **X-Y** connector and depress the **X-Y** button. A horizontal straight line must appear on the screen. In order to ascertain the horizontal deflection coefficient, divide the measured peak-to-peak voltage by the measured line length in div.

## Component Tester

After depressing the **CT** button, a horizontal straight line has to appear immediately when the **CT** socket is open. The length of this trace should be approx. **4 div. (50 Hz)**. After short-circuiting both **CT** sockets, a vertical straight line with approx. **4 div.** height should be displayed. The above stated measurements have some tolerances. They are dependent among other things on the mains/line voltage and frequency.

## Trace Alignment

The CRT has an admissible angular deviation  $\pm 5^\circ$  between the X deflection plane D1-D2 and the horizontal center line of the internal graticule. This deviation, due to tube production tolerances (and only important after changing the CRT), and also the influence of the earth's magnetic field, which is dependent on the instrument's North orientation, are corrected by means of the **TR** potentiometer. In general, the trace rotation range is asymmetric. It should be checked, whether the baseline can be adjusted somewhat sloping **to both sides** round about the horizontal center line of the graticule. With the HM 103-2 in its closed case, an angle of rotation  $\pm 0.57^\circ$  (0.1 div. difference in elevation per 10 div. graticule length) is sufficient for the compensation of the earth's magnetic field.

## Power Voltage Fluctuations

If a variable mains/line transformer is available, the characteristics of the HM 103-2 on power voltage fluctuations of  $\pm 10\%$ , referred to the voltage indicated by a triangle ( $\blacktriangledown$ ) above the fuse holder (rear panel), should be checked. Under these conditions no variations should be detected on the display in either the vertical or horizontal axis.



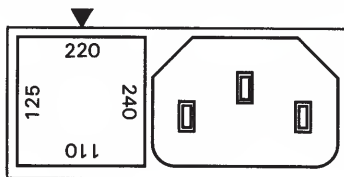
# Service Instructions

## General

The following instructions are intended as an aid for the electronic technician, who is carrying out readjustments on the HM 103-2, if the nominal values do not meet the specifications. These instructions primarily refer to those faults, which were found after using the Test Instructions. However, this work should only be carried out by properly qualified personnel. For any further technical information call or write to HAMEG. Addresses are provided at the back of the manual. It is recommended to use only the original packing material, should the instrument be shipped to HAMEG for service or repair (see also Warranty, page M 1).

## Mains/Line Voltage Change

The instrument has an appliance inlet at the rear. This unit contains the power fuse, which is interchangeable for the different mains/line voltages. The fuse holder with its square top plate can be pulled out by means of a small screwdriver (after disconnection of the power cord from the appliance inlet), and **changing of the power voltage** is possible by turning this plate 90 degrees for each of the four power voltages marked on the plate (see triangle **above** the fuse holder). The fuse holder should then be plugged in again in the desired position, which should be **the closest value of the measured mains/line voltage in your area**.



Required power fuse-link:

**5x20 mm, time lag** (slow-blow), **250 V ~, C**, to IEC 127/III; DIN 41662.

Mains/line voltage	Rated current
110 V ~ ± 10%	T0.315 A
125 V ~ ± 10%	T0.315 A
220 V ~ ± 10%	T0.16 A
240 V ~ ± 10%	T0.16 A

The power fuse has to match the set mains/line voltage and must be changed if necessary. It should be checked that only fuses of the specified type and current are used in this case. Patched fuses or short circuit of the fuse holder must not be used as an alternative.

## Instrument Case Removal

The rear cover can be taken off after two cross recessed pan head screws (M 4x30 mm) with two washers on it have been removed and after unplugging of the power cord's triple-contact connector. While the instrument case is firmly held, the entire chassis with its front panel can be withdrawn forward. When the chassis is inserted into the case

later on, it should be noticed that the case has to fit under the flange of the front panel. The same applies for the rear of the case, on which the rear cover is put.

### Caution

**During opening or closing of the case, the instrument must be disconnected from all power sources for maintenance work or a change of parts of components. If a measurement, trouble-shooting, or an adjustment on the opened instrument is unavoidable, this work must be done by a specialist, who is familiar with the risk involved.**

**When the instrument is set into operation after the case has been removed, attention must be paid to the accelerating voltage for the CRT – 1950 V – and to the operating voltages for both final amplifier stages – together 200 V. Potentials of these voltages are on the CRT socket, on the vertical Timebase Switch and HV PCB, and on the lower Main PCB. Such potentials are moreover on the checkpoint strip and on the single checkpoint K (CRT cathode) on the lower Main PCB. They are highly dangerous and therefore precautions must be taken. It is noticed furthermore that shorts occurring on different points of the CRT high voltage and unblanking circuitry will definitely damage some semiconductors and the opto-coupler. For the same reason, it is very risky to connect capacitors to these points while the instrument is on.**

**Capacitors in the instrument may still be charged, even when the instrument is disconnected from all voltage sources. Normally, the capacitors are discharged 6 seconds after switching off. However, with a defective instrument an interruption of the load is not impossible. Therefore, after switching off, it is recommended to connect one by one all terminals of the check strips on the upper and the lower PCBs across 1 kΩ to ground (chassis) for a period of 1 second.**

**Handling of the CRT needs utmost caution. The glass bulb must not be allowed – under any circumstances – to come into contact with hardened tools, nor should it undergo local superheating (e.g. by soldering iron) or local undercooling (e.g. by cryogenic-spray). We recommend the wearing of safety goggles (implosion danger).**

## Operating Voltages

Besides the two AC voltages for the CRT heating (6.3 V) and Component Tester (8.6 V) there are six DC operating voltages generated. The + 12 V, + 5 V, – 12 V, and the – 1950 V are electronically regulated. Only the – 1950 V value is adjustable. Both DC operating voltage for the X and Y final stages (+ 180 V and + 140 V) are not regulated. The AC

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mains/line voltage, set on the appliance inlet on rear panel, should be taken into account when measuring these values. If there are deviations of the regulated voltages of more than 5%, a fault exists in the circuit concerned. The adjustable voltage has to be set precisely for – 1950V by the adjustment of the 2.5k $\Omega$  potentiometer. This voltage is measured on the Checkpoint strip with reference to ground (see Adjusting-Plan). Measurements of the high voltage may only be accomplished by the use of sufficient highly resistive voltmeter (> 10M $\Omega$ ). You must make absolutely sure that the electric strength of the voltmeter is sufficiently high. It is recommended to check the ripple and also the interaction from other possible sources. Excessive values might be very often the reason for incomprehensible faults. The maximum ratings are specified on the circuit diagrams. For the measurement of the high voltage ripple, a probe capable of withstanding 2000V (e.g. x100 probe HZ53) is needed. But also a normal probe x10 is sufficient with a capacitor (10...22nF 2000V) connected in series to the probe tip.

## Maximum and Minimum Brightness

Two variable resistors of 500k $\Omega$  each, located on the Z-PCB, are used for these adjustment procedures (see Adjusting Plan). They may only be touched by a properly insulating screwdriver (Caution! High voltage!). The adjustments may possibly have to be repeated, because the functions of both variable resistors are dependent on each other. Correct adjustment is achieved, when the trace can be blanked while **X-Y** pushbutton is depressed and, in addition, when the requirement described in the Test Instructions are met.

## Astigmatism Correction

The ratio of vertical and horizontal sharpness can be adjusted by the variable resistor of 100k $\Omega$ , located on the lower Main PCB (see Adjusting Plan). As a precaution however, the voltage for the vertical deflecting plates (approx. +91V) should firstly be checked, because this voltage will affect the astigmatism correction. While the adjustment is being carried out (with pressed **X-Y** button and medium brightness), the **FOCUS** control knob has to be repeatedly turned to and fro until the shape of the luminous spot, whether round or oval or rectangular, stays the same to the right and left of the optimum focusing. The interaction of focus adjustment and astigmatism correction should be noted. After this adjustment, a square-wave signal should be displayed and verified once more in accordance with the Test Instructions. The final adjustment has always to be the **FOCUS** control.

## Trigger Threshold

The internal trigger threshold should be in the range 0.3 to 0.5div. display height. It is strongly dependent on the 710CN

comparator IC. If there are compelling reasons to replace this comparator, it may be that triggering becomes too sensitive or too insensitive caused by the IC gain tolerances (see Test Instructions: "Triggering Checks", page T2). In extreme cases, the R411 resistor (1.5M $\Omega$ ) between the pins 3 and 9 should be reduced by changing or parallel connection of another resistor. The optimum value should be tested. Generally, this value ranges between 470k $\Omega$  and 1.5M $\Omega$ . A too small trigger threshold cause double-triggering or premature trigger action due to interference pulses or random noise.

## Trouble-Shooting the Instrument

For this job, at least an isolating variable mains/line transformer (protection class II), a signal generator, an adequate precise multimeter, and, if possible, an oscilloscope are needed. This last item is required for complex faults, which can be traced by the display of signal or ripple voltages. As noted before, the regulated high voltage (– 1950V) and the supply voltage for the final stages (approx. 220V) are highly dangerous. Therefore it is recommended to use **totally insulated extended probe tips**, when trouble-shooting the instrument. Accidental contact with dangerous voltage potentials is then unlikely. Of course, these instructions cannot thoroughly cover all kinds of faults. Some common-sense will certainly be required, when a complex fault has to be investigated.

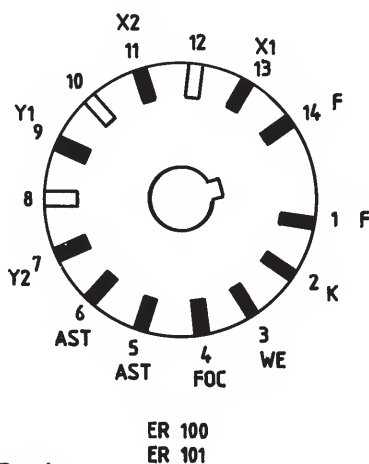
If trouble is suspected, visually inspect the instrument thoroughly after removal of the case. Look for loose or badly contacted or discolored components (caused by overheating). Check to see that all circuit board connections are making good contact and are not shorting to an adjacent circuit. Especially inspect the connections between the PCBs, to the power transformer, to front chassis parts (**AC/DC** button, **GD** button on YE-Board; **CT** sockets; LED, **CAL.** output eyelet), to CRT socket and to trace rotation coil (inside of CRT's shielding). Furthermore, the soldering connections of both Y-final stage transistors and the + 12V fixed three-terminal regulator on the rear chassis should be inspected. This visual inspection can lead to success much more quickly than a systematic fault location using measuring instruments. Prior to any extensive trouble-shooting, also check the external power source.

If the instrument fails completely, the first and most important step – **after checking the mains/line voltage and power fuse** – will be to measure the deflecting plate voltages of the CRT. In almost any case, the faulty section can be located. The sections represent:

1. Vertical deflection.
2. Horizontal Deflection.
3. CRT circuit.
4. Power supply.

While the measurement takes place, the position controls of both deflection devices must be in mid-position. When the deflection devices are operating properly, the separate

voltages of each plate pair are almost equal then ( $Y = +91\text{ V}$  and  $X = +99\text{ V}$ ). If the separate voltages of a plate pair are very different, the associated circuit must be faulty. An absent trace in spite of correct plate voltages means a fault in the CRT circuit. Missing deflection plate voltages is probably caused by a defect in the power supply.



Voltages at the CRT socket

## Replacement of Components and Parts

For the replacement of parts and components use only parts of the same or equivalent type. Resistors without specific data in the diagrams have a power dissipation of 0.25 Watt and a tolerance of 2 %. Resistors in the high voltage circuit must have sufficient electric strength. Capacitors without a voltage value must be rated for an operating voltage of 63V. The capacitance tolerance should not exceed 20%. Many semiconductors are selected, especially all amplifier transistors, which are contained in push-pull circuits. If a selected semiconductor is defective, both push-pull transistors of a stage should be replaced by selected components, because otherwise there are possibly deviations of the specified data or functions. The HAMEG Service Department can give you advice for troubleshooting and replaceable parts. Replacement parts can be ordered by letter or telephone from the nearest HAMEG Service Office. Please supply the following information: Instrument type and serial number, description of the part (including function and location in the instrument), quantity desired.

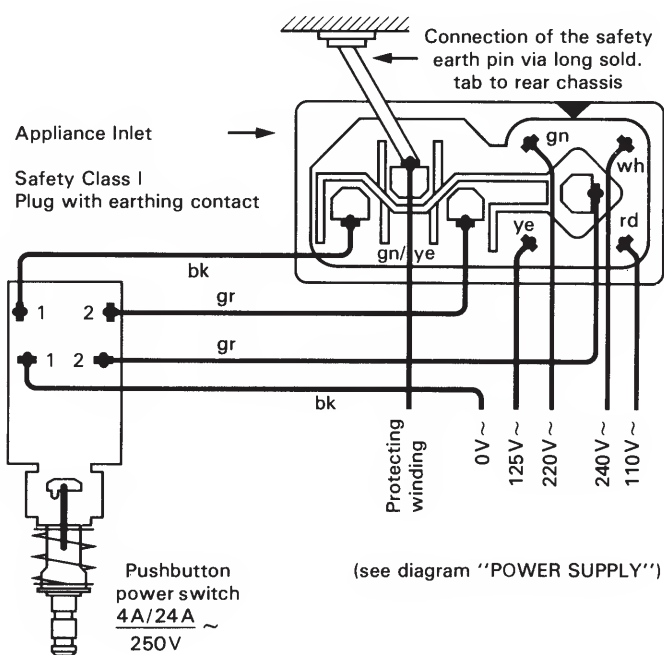
When **CRT replacement** is necessary, the range of the trace rotation device should be checked. In doing so, it may be found that the setting range of the **TR** potentiometer is not sufficient due to the extreme difference of the trace alignment between the old and the new CRT (caused by angular deviation of  $\pm 5^\circ$  during sealing of the base in neck of tube). This deviation can be eliminated by inserting an **additional resistor**  $\geq 680\Omega$  0.25W between trace rotation coil terminal TR1 and either + 12V or - 12V (stop terminals on the TR pot). Such a resistor may already have been inserted during scope production, but now possibly con-

nected to the wrong voltage polarity. If the optimum resistance value is tested, the TR pot should be set previously to its approximate mid-range. This test reduces warming-up of the TR pot and permits very fine trace rotation alignment.

## Replacement of the Power Transformer

Should it be necessary to replace the mains/line transformer, the correct terminal sequence (color identification) for primary and secondary windings must be followed (see diagram "Power Supply" and the figure below). In addition, the relevant Safety Regulations must be observed. Here, we refer only to those requirements relative to the parts conductively connected to the supply mains:

- The construction of the instrument shall be such as to prevent any short-circuiting or bridging of the insulation, clearances or creepage distances between those parts connected to the supply mains and any accessible conductive parts due to accidental loosening or freeing of the wiring, screws, etc.
- The rigidity of the mains wiring connections, which may be subject to mechanical stresses, shall not be dependent upon the soldering alone. To meet this requirement, the bare ends of the wires must be pushed through the holes in the respective soldering tab, bent over with a pair of pliers, and subsequently fixed by soldering.
- The minimum cross section of the protective earth connection between the instrument's power inlet and the connecting soldering tab on the rear chassis must be  $0.81\text{ mm}^2$  in North America and  $0.75\text{ mm}^2$  in Western Europe. The connecting soldering tab on the rear chassis has to be secured mechanically against loosening (e.g. with lock washer).



Rear View of Power Switch and Appliance Inlet with Voltage Selector and Fuse



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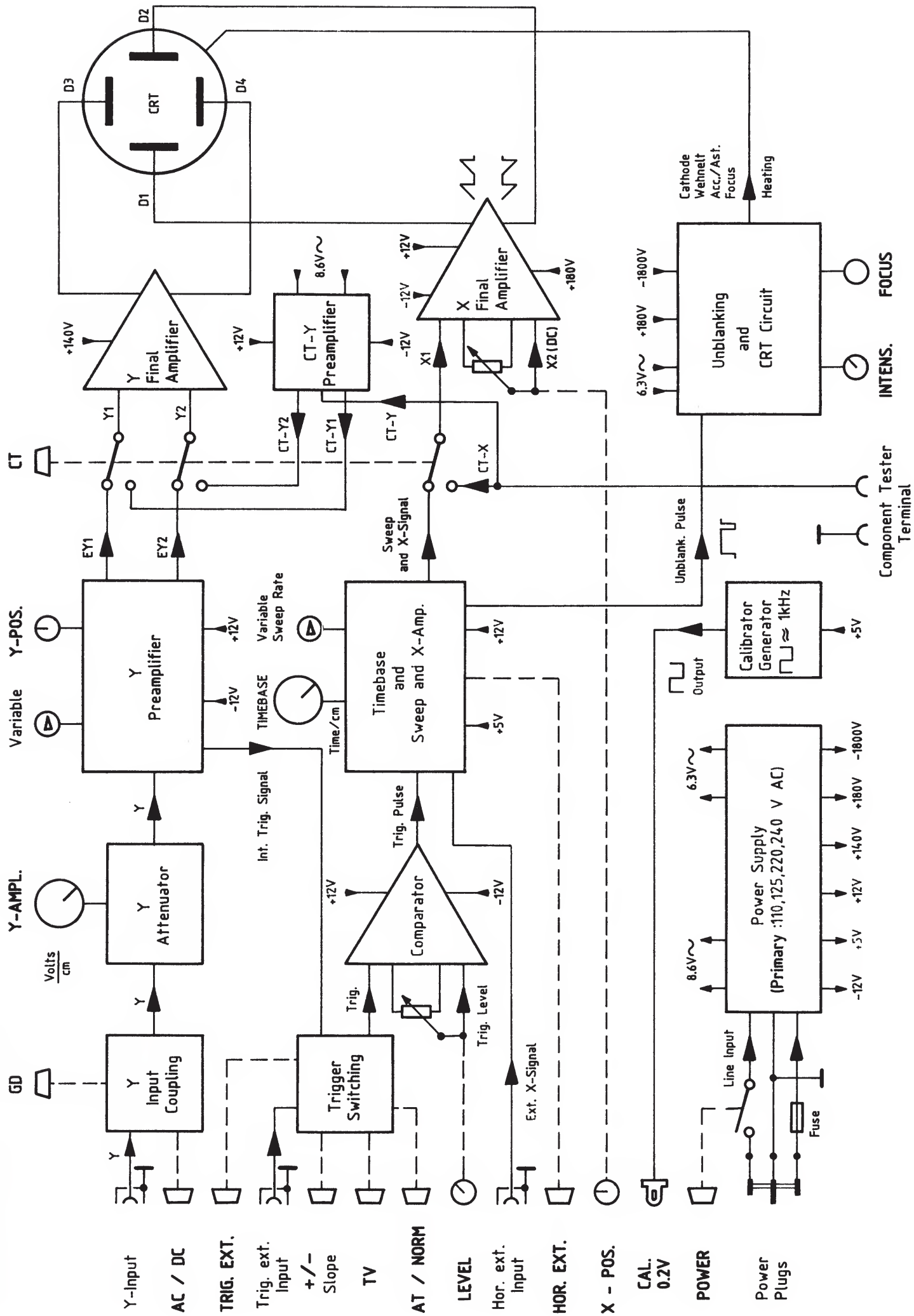
After replacing the power transformer, all remaining bits of wire, solder and other foreign matter must be removed from the PCBs, the vicinity of the power transformer and from within the insulating connecting box by shaking, brushing and blowing. Finally, the top plate of the insulating connecting box has to be replaced. Before connecting the instrument to the power supply, replace the possibly defective fuse, press the **POWER** button and make sure that there is an adequate insulation state between chassis (= safety earth conductor) on the one hand, and the live/line pin as well as the neutral pin, on the other. Only after proper insulation has been established may further function tests with open chassis follow, but with appropriate precautionary measures.

## Adjustments

As advised in the Operating, Test and Service Instructions, small corrections and adjustments are easily carried out with the aid of the Circuit Diagrams and **Adjusting Plan**. However, a complete recalibration of the scope should not be attempted by an inexperienced operator, but only someone with sufficient expertise. Several precision measuring instruments with cables and adapters are required, and only then should the pots and trimmers be readjusted, provided that the result of each adjustment can be exactly determined. Thus for each operating mode and switch position, a signal with the appropriate sine or square waveform, frequency, amplitude, risetime and duty cycle is required.



## Basic Block Diagram

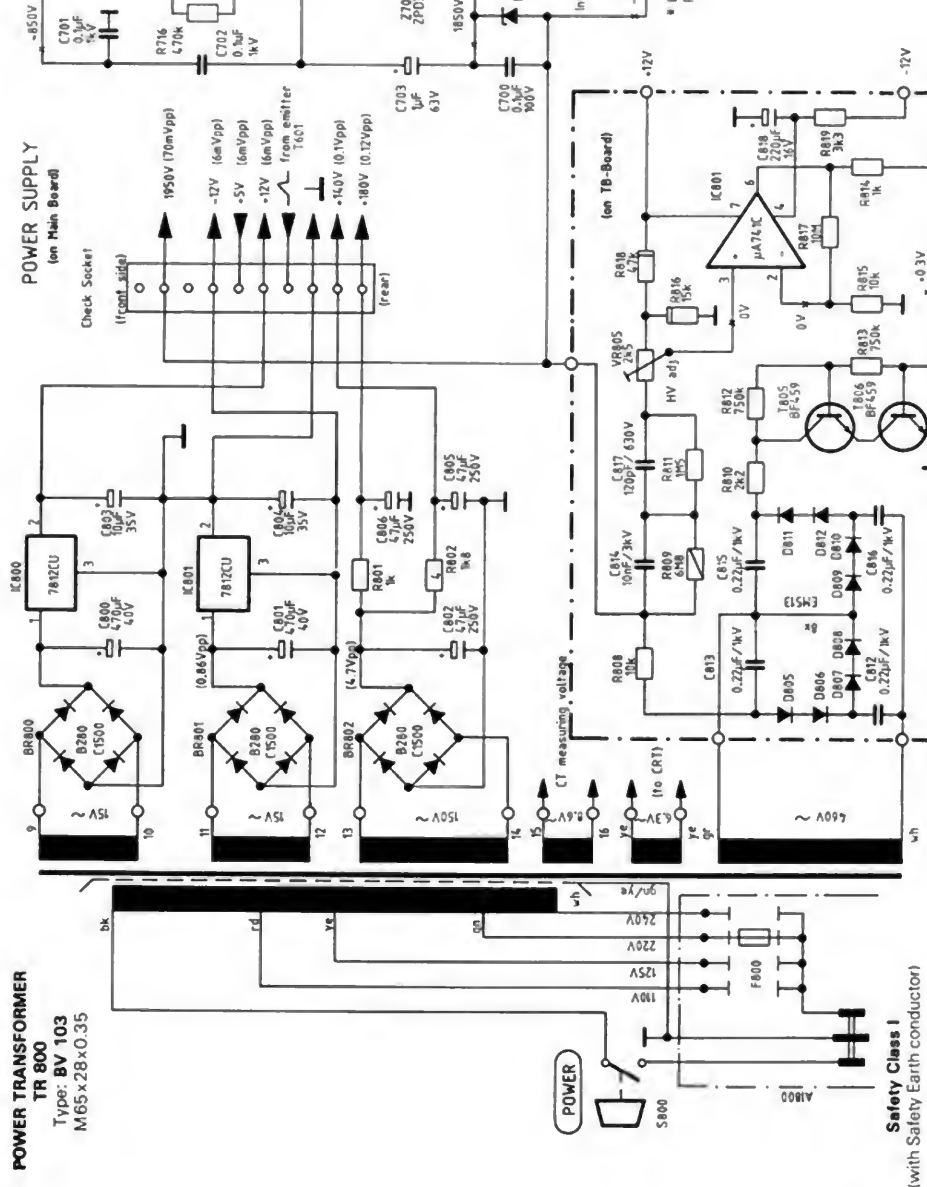


## Power Supply, CRT and Unblanking Circuit, Calibrator, Trace Rotation

HM103-2

**POWER TRANSFORMER**

TR 800  
Type: BV 103  
M65x28x0.35



**Safety Class I**  
(with Safety Earth conductor)

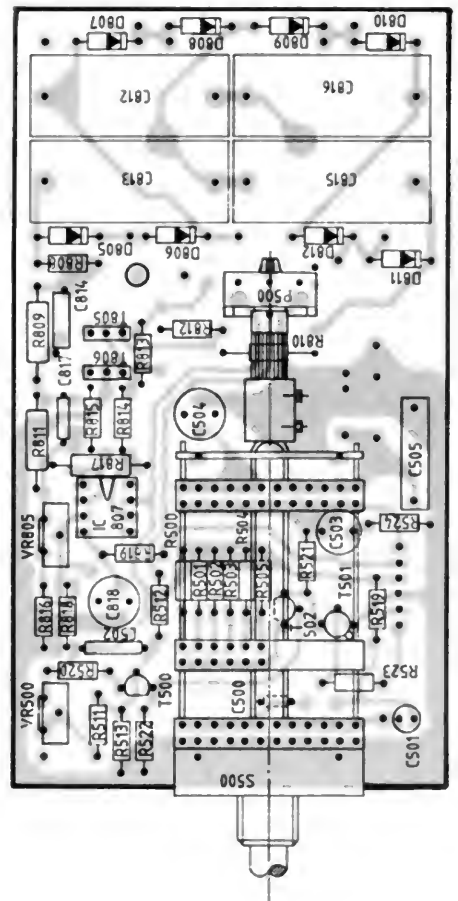
AC 50... 60Hz

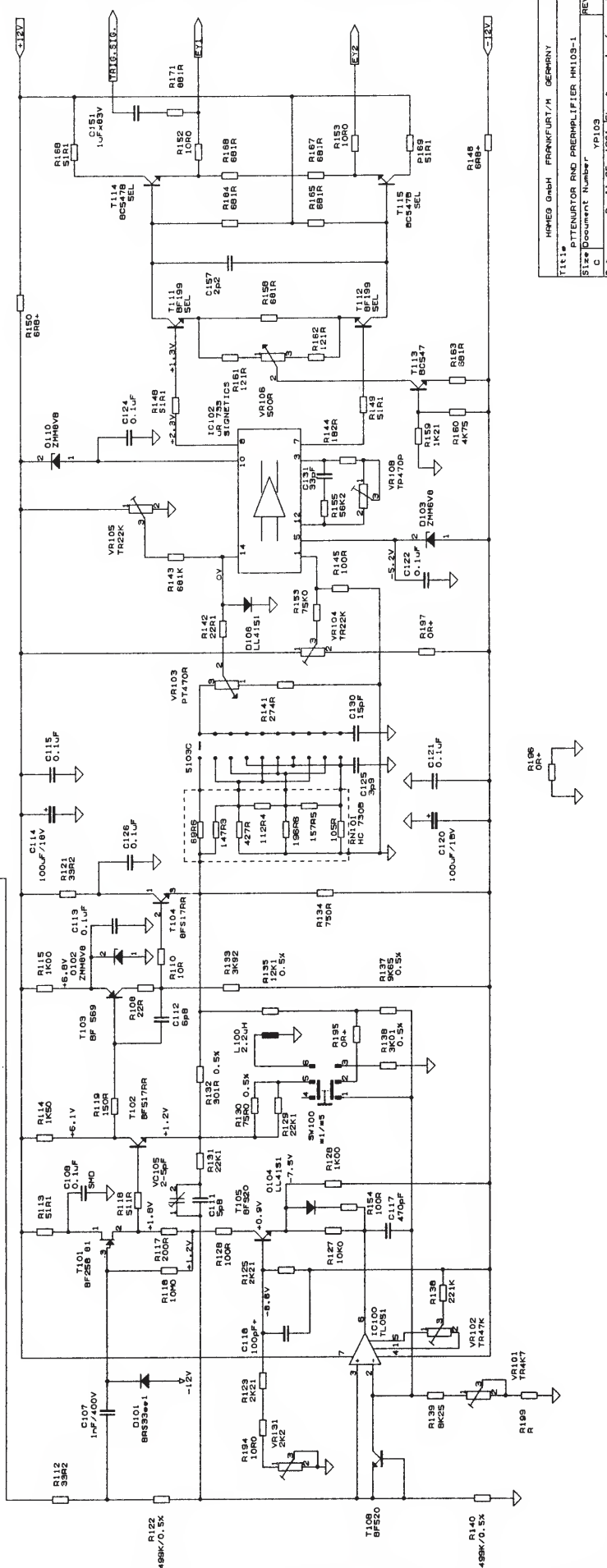
**POWER FUSE LINKS**

Type: IEC 127-III  
DIN 41662  
SEV 1064  
BS 4265

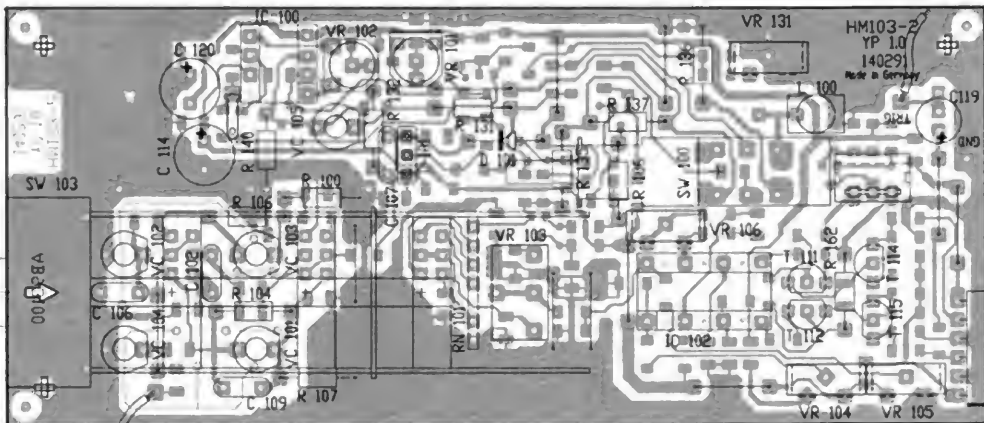
5x20mm, time lag  
110V ±10% T 0.315 A  
125V ±10% T 0.315 A  
220V ±10% T 0.16 A  
240V ±10% T 0.16 A

WATTS (max.): 23  
AMPS (max.): 0.12  
at 220V 50Hz

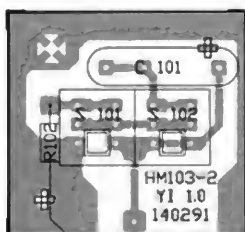
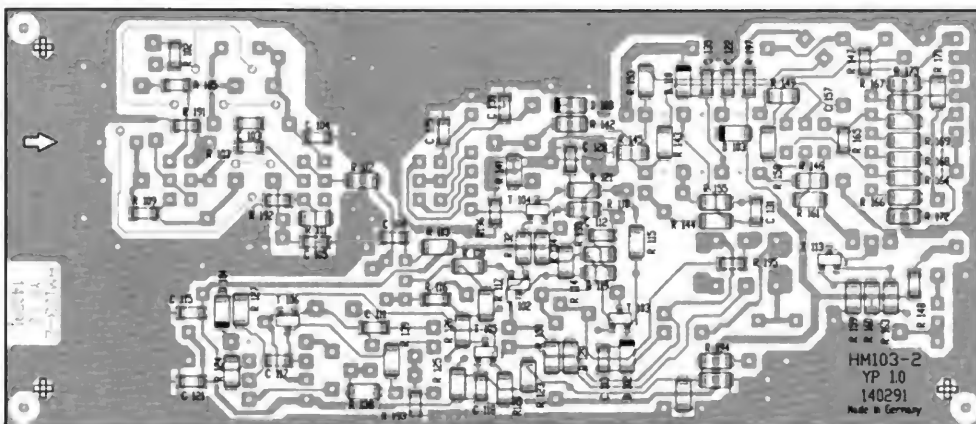
**COMPONENT LOCATIONS TB-BOARD (with HV-Regulation)**



## HM 103-2



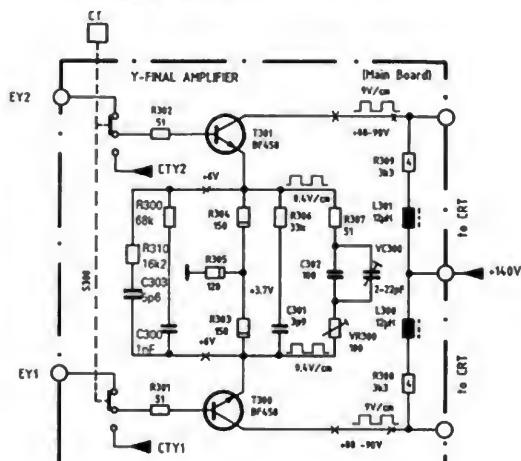
## HM 103-2



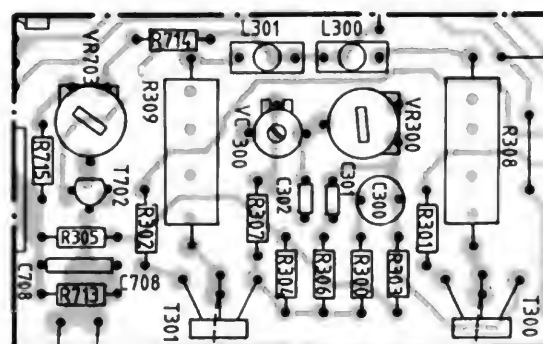
## Component Locations

YI-Board	HM 103-2
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## HM 103-2

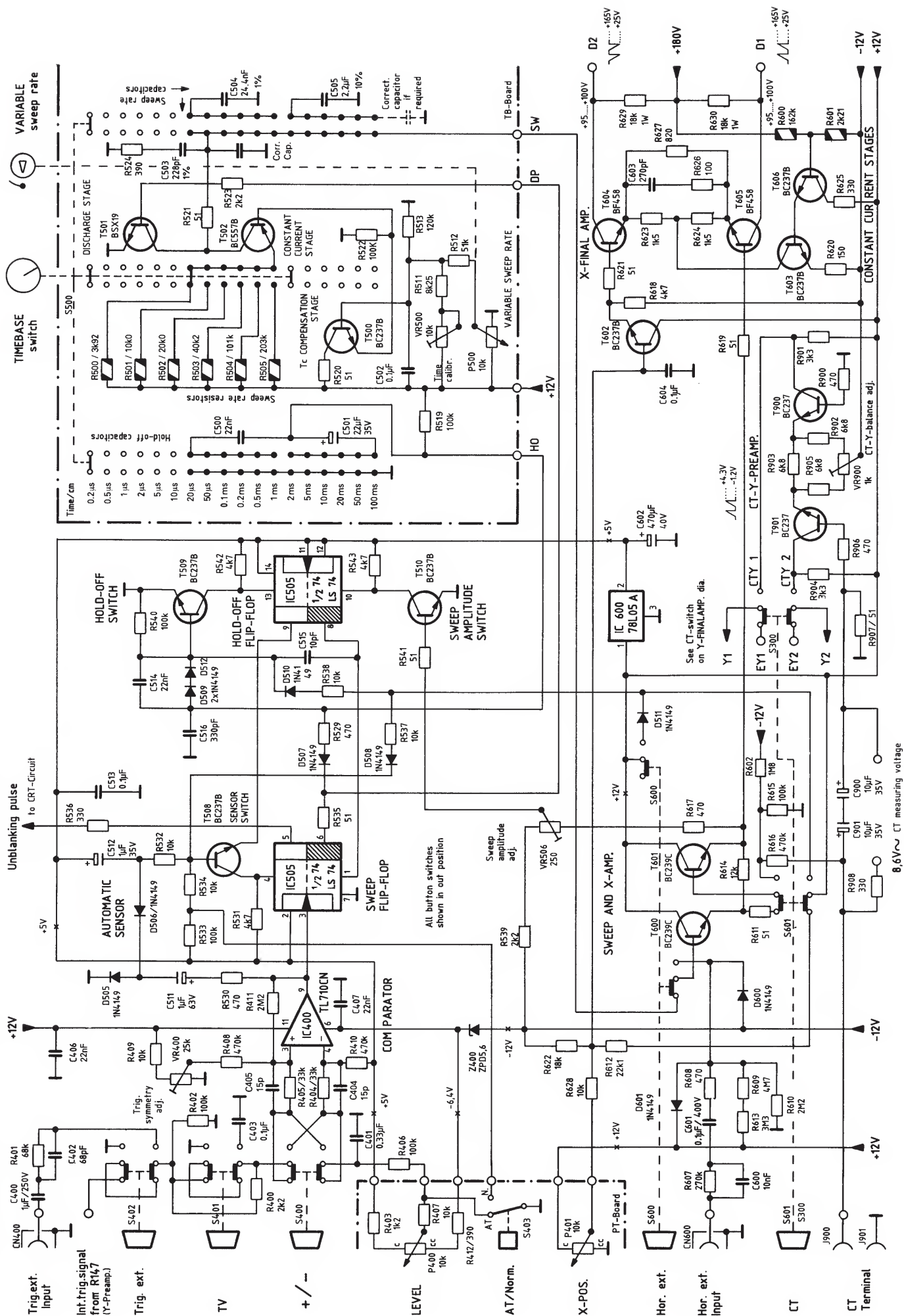


### Component Locations Y-Final Amp. HM 103-2

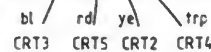


(Section of the Main Board — nearby rear chassis)

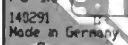




## HM 103-2



## HM 103-2



Electrical components on certain parts of the HM 103 are marked such that the first numeral is on:

- Y-Input, Attenuator and Y-Preamplifier1..
- Y-Final Amplifier3..
- Trigger Circuit, Comparator4..
- Timebase5..
- Sweep and X-Amplifier, X-Final Amplifier6..
- CRT Circuit, Trace Rotation, Calibrator7..
- Power Supply, LED8..
- CT-Y-Preamplifier9..

Color-Abbreviations for insulated wire			
bk = black	ye = yellow	gr = grey	
bn = brown	gn = green	wh = white	
rd = red	bl = blue	trp = transparent	
or = orange	vi = violet	gn/ye = green/yellow stripe	

Types and Terminals of Transistors and some ICs	BC237B BC239C BC557B BF297	BF199 BF440	MPS918	BF458 BF459 BUX86/87 BD232	BSX19	U440	78XXCU  The – 12V Regulator requires an insulation for package and screw to the chassis.
Bottom View							
Top View							

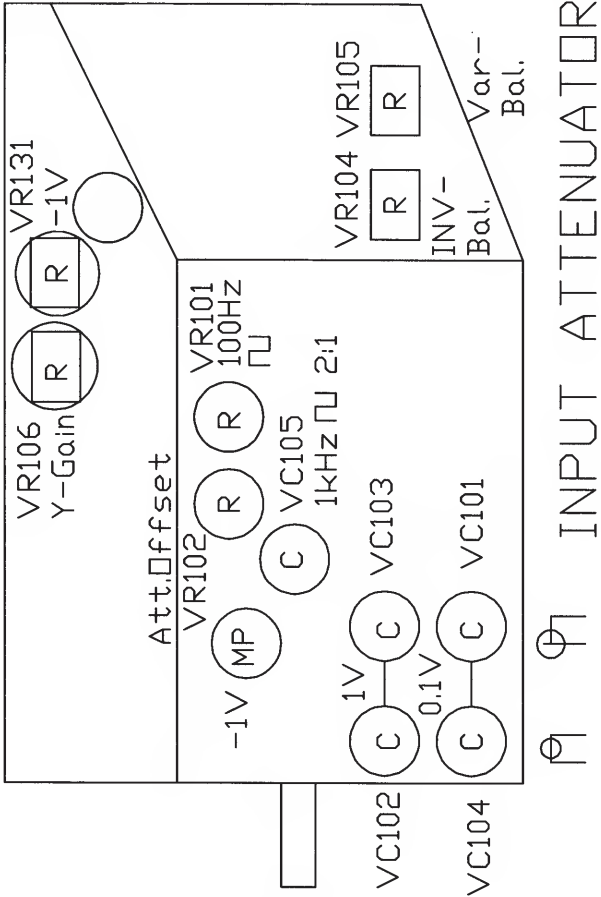
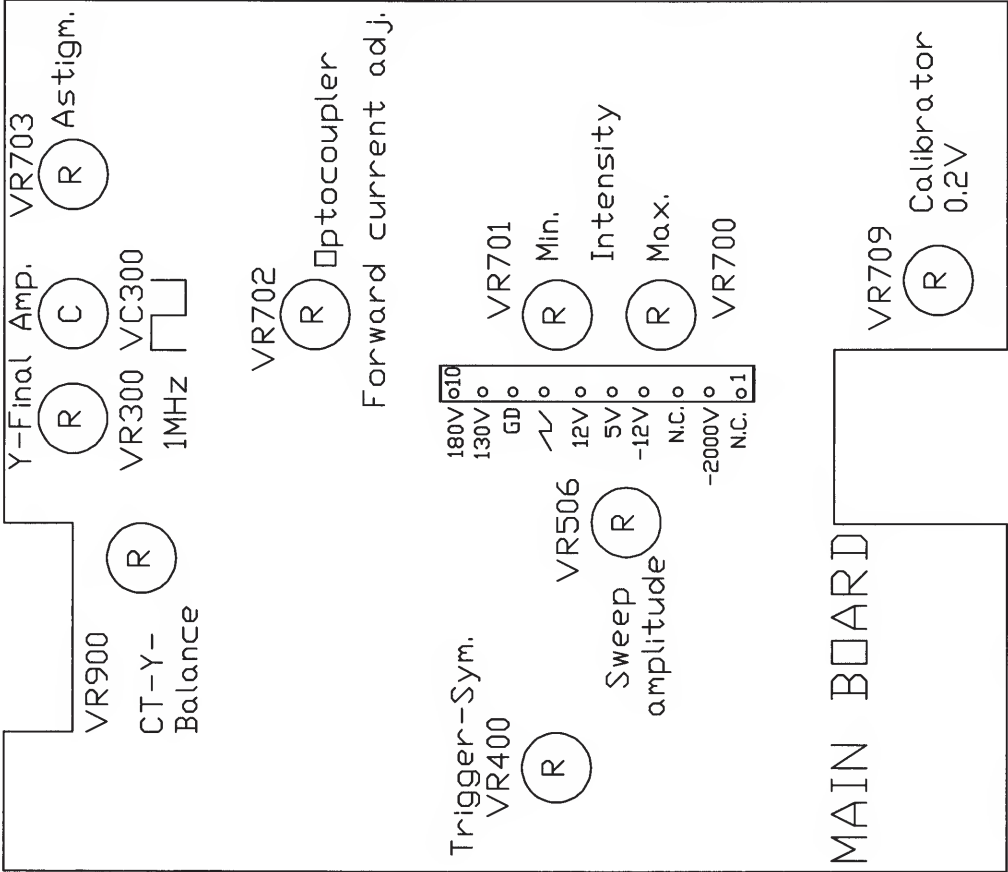
Abbreviations

- Al...Appliance inlet
- BR...Bridge rectifier (Silicium)
- C...Capacitor (fixed)
- ChP...Check point
- CN...Connector
- CRT...Cathode-ray tube
- D...Diode (Silicium)
- E...Eyelet (Calibrator)
- F...Fuse
- IC...Integrated circuit
- L...Inductor, Coil
- LED...Light emitting diode
- R...Resistor (fixed)
- S...Switch
- T...Transistor (Silicium)
- TR...Transformer
- VC...Variable capacitor
- VR...Variable resistor
- Z...Z-Diode

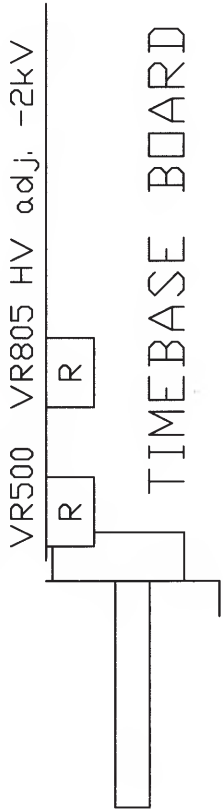
Resistor Identification

- Resistor 0.25W 2% (carbon film)
- Resistor 0.25W 1% tc = 50 · 10-6/K (metal film)
- Resistor 0.25W 0.5% tc = 50 · 10-6/K (metal film)
- Resistor 0.5W 2% (or for HV) (carbon film)
- Resistor 4W 2% tc = 400 · 10-6/K (metal oxide film)

# HM 103-2



Time-Cal. 50us/Div.





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